C O N T E N T S.

COMPRESSION PARAPLEGIA.

Introduction.

The subject of this Thesis is Compression Paraplegia, a term which I use in the generally accepted sense of all those conditions in which there is pressure upon the cord, whether a true motor paraplegia in the narrower sense of the word, that is paralysis of the lower limbs, is present or not.

The subject therefore includes such conditions as spinal tumour, morbid conditions of the lepto-and pachymeninges, spinal caries, malignant disease of the spine and so on. It should also have embraced injuries to the spinal column, but I have excluded the consideration of traumatic paraplegia, my desire being to study more especially the more chronic forms of the condition.

I have devoted particular attention to certain of these conditions, dealing only briefly with others, such as spinal caries, since to have discussed these exhaustively would have led me into details of medicine and surgery outside the scope of neurology.

Part I.

I have divided the essay into two main divisions. In the first I have endeavoured to correlate the signs

and symptoms of the condition with the anatomy and physiology of the structures involved. It has been necessary to deal only quite briefly with the general anatomy of the spinal cord and the canal in which it lies and with the tracts and nerves concerned with motor functions. The sensory functions,however, demand somewhat fuller consideration. During the last few years a large amount of valuable work has been accomplished, notably by Head, well nigh revolutionising our conceptions of the subject.

My own observations on compression paraplegia are fundamentally in accord with the main lines of modern research. I have therefore explained somewhat fully the grouping of the various sensory impulses in so far as they are concerned with the disorders under review, more especially the remarkable change which occurs in the cord as compared with the peripheral nervous system.

The principle symptoms and signs of compression paraplegia are associated with the spinal roots,the cord itself and the spine. These symptoms are next discussed seriatim. In as much, however, as the involvement of these structures both in point of time and distribution varies remarkably according to the particular nature and site of the lesion - a spinal tumour, for instance, differing in its nature from that of a

meningeal or vertebral affection - I have considered it advisable to deal with the symptoms from this point of view in a short section.

To complete the symptomatology of the condition there remains yet to be described certain general symptoms such as alterations in the respiratory, cardiac and vasomotor systems and the consideration of the effect of the level of the lesion upon the symptomatology of any individual case. These are dealt with in a short chapter in which I have included the motor and sensory localisation of the spinal cord.

Part II.

In the second part I have considered more in detail the various extra-medullary disorders with which compression paraplegia may be associated.

For this purpose I have collected and analysed a series of cases of compression paraplegia to which I have added cases which clinically simulated compression paraplegia but which operation or post-mortem examination proved to be due to other causes.

Material.

The material on which this thesis is based has been obtained chiefly from the records of cases in the National

Hospital, most of which I have had the opportunity of observing myself. I have also made use of cases which have been under my care in private or in other hospitals.

I wish to record my thanks to my colleagues on the staff of the National Hospital for their kindness and courtesy in permitting me to make use of their cases.

I have endeavoured as far as possible to use only those cases in which the morbid condition underlying the paraplegia has been ascertained by operation or post-mortem examination.

The advances which have been made in modern methods of investigation of cases of nervous disease have rendered some of the clinical records incomplete, so I have in several instances made use of such cases only in connection with special points.

I have not availed myself of all the cases of spinal caries or malignant disease contained in the records, as to have done so would have unduly extended the citation of cases without adding much of clinical importance.

I have excluded cases of traumatic origin, partly because they do not throw any light upon the question of differential diagnosis and partly because it is impossible to allocate the symptoms with any degree of certainty to the intra- and extra-medullary lesions present in these cases.

I have arranged the cases into different groups according to the situation of the extra-medullary lesion in relation to the spinal cord. This classification is of course more or less arbitrary, but is the most satisfactory from the clinical stand-point. I have further endeavoured to sub-divide these groups according to the nature of the lesion.

Extra Thecal.

Vertebral. Caries.
Sarcoma.
Carcinoma.

Tumours of Peri Thecal Space.

Hydatids

Intra Thecal.

Tumours

Diseases of the Meninges.

During the past few years there has been a steady advance in the recognition of the various forms of paraplegia which has led more and more to the separation of paraplegia due to general disease from that due to local spinal conditions both within and without the cord. Paraplegia due to local lesion may be separated into three groups.

(1) Cases due to acute intramedullary lesions - vascular or inflammatory.

(2) Cases due to chronic intra-medullary - such as syringo-myelia and intra-medullary growths.

(3) Cases due to compression of the cord.

It is not as a rule difficult to distinguish paraplegia due to vascular and inflammatory conditions from the other two groups, but it may be no easy matter to differentiate paraplegia due to intra-medullary growths from that due to extra-medullary pressure, as in both there may be symptoms of intra-medullary lesion.

Formerly certain syndromes, especially dissociated sensory loss, were regarded as conclusive evidence of an intra-medullary lesion, but the study of cases of compression paraplegia has convinced me that they may be common to both. It is necessary therefore to rely

upon other signs and symptoms to distinguish the two conditions, notably those which indicate the presence of an extra-medullary lesion. Further, if the paraplegia is undoubtedly due to an extra-medullary lesion a diagnosis as to the nature and site of the lesion has still to be made. The difficulty in making a differential diagnosis in these cases varies in great degree; in some the problem is simple, in others its solution is well nigh impossible.

The importance from the point of view of treatment of recognising the disease underlying the paraplegia is obvious and is daily becoming greater with the improvement of surgical technique.

I have therefore thought that it would prove instructive to collect and analyse a series of cases of compression paraplegia with the particular object of demonstrating - (1) that the diagnosis depends rather upon the recognition of the accessory or incidental symptoms than of those due to involvement of the cord itself; and (2) that the differential diagnosis of the various forms of compression paraplegia can be attained only by a careful study of the symptoms as regards their character, distribution, and the sequence in which they arise.

ANATOMICAL CONSIDERATIONS.

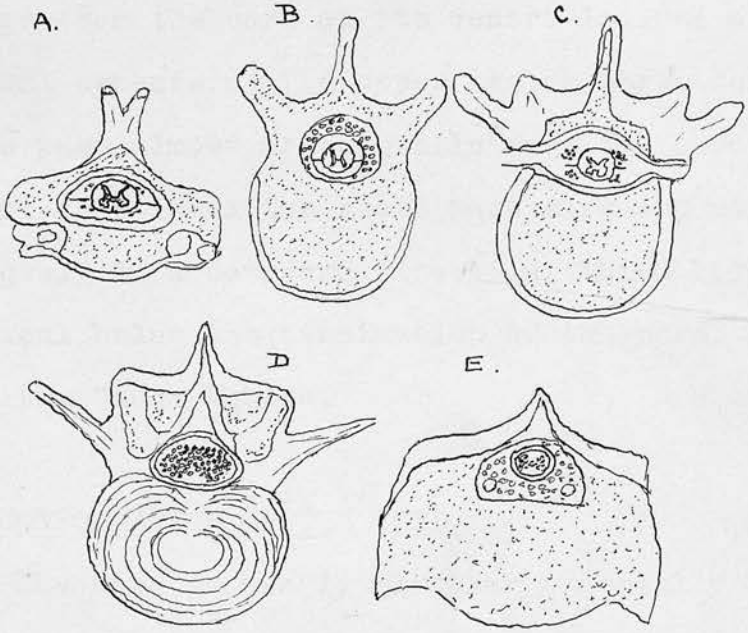
General Anatomy of the Spinal Cord and its relation to surrounding structures.

Tracts of the Spinal Cord.

GENERAL DESCRIPTION OF THE SPINAL CORD AND ITS RELATIONS TO THE SURROUNDING STRUCTURES.

The spinal cord lies more or less loosely in the vertebral canal enclosed in the theca, which is separated from the walls of the bony canal. The theca is loosely attached to the cord and separated from it by the sub-dural space, the arachnoid membrane, the sub-arachnoid space and the pia mater.

Sections shewing the general relations of the spinal cord to the theca and of the theca to the vertebral canal.



Key & Retzius (Quains Anatomy).

Sections through A. 5th Cervical Vertebra
B. 10th Dorsal Vertebra
C. 1st Lumbar Vertebra
D. Disc between 2nd & 3rd Lumbar Vertebrae
E. 1st Sacral Vertebra.

THE SPINAL CORD.

The spinal cord is about 18 inches long and extends from the region of the Foramen Magnum to, approximately, the lower part of the first lumbar vertebra, where it tapers and ends in a slender filament, the filum terminale, which passes down to be attached to the lower end of the sacral canal.

Spinal nerves arranged in pairs emerge from the cord at intervals along the course and pass to the corresponding inter-vertebral foramina. Each nerve is attached to the cord by two roots, a ventral or anterior, and a dorsal or posterior. These roots emerge from the cord on its ventro-lateral and dorso-lateral aspects. The upper two or three cervical roots pass almost horizontally from the cord, but below this level the roots pass more and more obliquely in a downward direction, which becomes nearly vertical below the termination of the cord, where they form the Cauda Equina.

THE CONFORMATION OF THE CORD.

The cord is nearly circular especially in the thoracic region, but it is somewhat flattened from before backwards so that in the whole of its course

the transverse diameter is greater than the antero-posterior. The cord is not of uniform diameter, it is enlarged in the cervical region and in the lumbar region. This enlargement is due to an expansion in the transverse diameter. The cervical enlargement extends from the upper limit of the cord to the body of the 1st or 2nd dorsal vertebra and from it come the large nerves which supply the upper limbs. The lumbar enlargement extends from the 10th dorsal vertebra to the upper border of the 1st lumbar and from it arise the large nerves which supply the lower limbs. In this enlargement the cord is increased in both antero-posterior and transverse diameters.

FISSURES.

The spinal cord is incompletely divided into a right and a left half by two median fissures, which pass in from the anterior and posterior surfaces and extend through the greater thickness of the cord. The anterior median fissure is wide and only extends in for about one third of the thickness of the cord. The posterior median fissure which extends about half way through the cord, is not a true fissure.

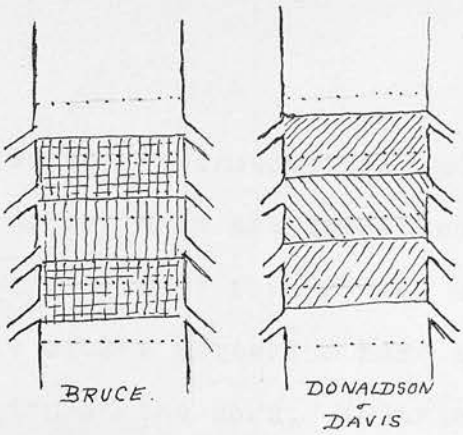
RELATION BETWEEN THE SPINES OF THE VERTEBRAE AND THE PLACES OF ATTACHMENT OF THE NERVE ROOTS TO THE CORD.

This varies considerably, but the following relations are fairly constant. The 1st dorsal root is attached to the cord opposite the 6th or 7th cervical spine; the 7th dorsal root is attached opposite the 4th or 5th dorsal spine. The cervical enlargement corresponds roughly in vertical extent with the spines of the cervical vertebræ while the lumbar enlargement corresponds with the spines of the 10th 11th and 12th dorsal vertebræ and the interval between the last named and the 1st lumbar.

The line of origin of the sacral nerves corresponds in vertical extent with the body of the 1st lumbar vertebra.

SEGMENTS OF THE SPINAL CORD.

The portion of the cord corresponding to the attachment of each pair of spinal nerves is termed a segment. A. Bruce(1) defined the limit of a spinal segment as being from the lowest thread of one root to the lowest thread of the root below, while Donaldson and Davis(2) define it as being from the highest thread of one root to the highest thread of the root above.



INTERNAL STRUCTURE OF THE SPINAL CORD.

Grey matter. On transverse section of the spinal cord grey matter is seen to occupy the more central parts being almost completely enclosed by white matter. It is arranged in the form of a letter H, the uprights being crescentic with the concavity facing outwards and laterally, the convexities face inwards and are united across the middle line by the dorsal grey commissure: the ends of each crescent are named from their position, the anterior or ventral horns and the posterior or dorsal horns. The anterior horns are shorter and broader than the posterior and are everywhere separated from the surface of the cord by white matter. The posterior horns are long and narrow and taper to form two points which almost extend to the external surface of the cord. The ventral horns contain the nerve cells from which the anterior roots arise. About the middle of the grey crescent from the upper segments of the lumbar cord into the cervical region there is a column of cells, intermedio-lateral tract. There is also a column of cells lying about the

middle of the crescent, intermediate or middle nucleus. The cells in the dorsal horn are described according to their situation, the largest form a well marked group at the inner angle of the posterior horn and extend up the dorsal region of the cord. (Clarke's Column).

Central Canal. A minute canal extends through the whole length of the spinal cord in the substance of the grey commissure. It varies in shape and size in different regions - above, it extends into the medulla oblongata to end in the 4th ventricle, below, it ends near the extremity of the conus medullaris in a T shaped expansion continuing to a blind end in the filum terminale. The canal is lined with a layer of ciliated epithelium.

White Matter. This surrounds the grey matter completely, except opposite the dorsal horns which separate off the dorsal columns from the rest of the cord. The rest of the white substance is arbitrarily divided into anterior and lateral columns by the passage of the anterior nerve roots from the anterior horn to the surface of the cord.

BLOOD SUPPLY.

Arteries. The arterial supply is derived from the vertebral arteries and is reinforced by the inter-

costal and other arteries.

1. The anterior spinal artery runs along the cord opposite the anterior median fissure into which branches are given off which divide to right and left to supply the grey matter in the central portion of the cord and a certain amount of white matter.

2. The posterior spinal arteries run one on each side of the cord passing along the cord in front of the line of attachment of the posterior root and supplying the grey and white matter.

3. The cord is also supplied by vessels which pass in from the periphery. These supply the periphery of the cord, and the larger branches penetrate to the grey matter and supply those parts not served by the other vessels.

Veins. The two chief veins are the anterior median running along with the anterior spinal artery, and the posterior median vein running along the posterior median fissure. There is also a venous plexus over the posterior surface of the cord and behind the exit of the nerve roots. In the upper part the veins join those of the cerebellum and pons and the sinuses round the foramen magnum.

Lymph Paths. There are no true lymphatic vessels, the lymph finds its way out of the cord by means of perivascular spaces in the tunica adventitia of the blood vessels. The perivascular spaces communicate with the sub-arachnoid space. (Key and Retzius).

THE SPINAL PIA MATER.

This membrane is thicker, firmer and less vascular and more adherent to the nervous tissues than the encephalic pia mater. A fold of this membrane passes into the anterior fissure of the cord and a thinner process passes into the posterior fissure. It becomes continuous with the connective-tissue sheath of the spinal roots.

THE SPINAL ARACHNOID MATER.

The arachnoid forms a loose sheath for the spinal cord, being separated from the pia mater by a space - the sub-arachnoid space, and from the dura by the sub-dural space. Below the cord it forms a tubular sheath for the nerve roots of the cauda equina and acts as a large reservoir for cerebro-spinal fluid. Where the spinal roots pass through the dura the arachnoid is prolonged for a short distance as a sheath which eventually blends with the epineurium and perineurium.

An injection driven into either the sub-arachnoid or sub-dural space passes along the nerves to the limbs, showing that there is continuity between the sub-arachnoid space and the lymphatic spaces in the nerves.

THE SPINAL DURA MATER.

The dura is firmly attached to the margin of the foramen magnum. Within the vertebral canal it forms a loose sheath, the theca, round the cord and is not directly adherent to the bone. It ends opposite the second sacral vertebra and the dura mater is prolonged downwards as a fibrous band which spreads out and is attached to the periosteum of the lower end of the sacral cord.

The theca is fixed in its position mainly by its lateral prolongations on the spinal nerve roots, but also by ligamentous bands which pass from it to the walls of the spinal canal. The most important of these connect the anterior part of the theca to the posterior common ligament. The union is firmest opposite the axis, from this level to the third or fourth lumbar vertebra rather loose fibres pass, to be attached to the lateral borders of the posterior common ligament. Below this level these fibres form a median ventral septum.

THE CIRCUM DURAL SPACE.

The space between the dura and the walls of the vertebral canal is occupied by areolar tissue, loose fat and by a plexus of spinal veins.

TRACTS OF THE SPINAL CORD.

A. DESCENDING TRACTS OF THE VENTRO LATERAL COLUMNS.

Pyramidal Tracts. The pyramidal fibres derived from the motor cells in the cortex for the most part decussate at the upper limit of the spinal cord and pass down in the lateral columns occupying, on transverse section, a somewhat triangular area lying in the angle between the dorsal horn and the outer surface of the cord, but separated from both. This tract is known as the crossed pyramidal tract and it can be traced down as far as the 3rd sacral segment. The tract becomes smaller as it passes down the cord and its situation nearer the surface of the cord. The fibres end in connection with the grey matter by collateral fibres which link them up to the anterior horn cells of the spinal cord. Those fibres which do not cross in the decussation of the pyramidals, form the direct or uncrossed pyramidal tract. This tract gradually diminishes and ends about the mid-thoracic region. It is probable that the fibres of the direct pyramidal tract decussate through the ventral commissure, and through the grey matter of the opposite side to reach the lateral pyramidal tract on the other side of the cord. Other fibres which do not cross pass to the lateral

column of the same side where they join the fibres which have crossed from the opposite pyramidal - they constitute the uncrossed lateral pyramidal tract.

The Anterior Marginal Tract (bundle of Loewenthal) This tract consists of fibres situated round the circumference of the ventral aspect of the ventro lateral column. Its fibres are continuous with

1. Those of the dorsal longitudinal bundle (vestibulo spinal tract) of the medulla oblongata. They are derived chiefly from both Deiter's nuclei and from scattered cells of the reticular formation of the medulla oblongata, pons and tegmentum.

2. The ventral longitudinal bundle (tecto spinal tract) of the pons and medulla oblongata. These fibres terminate and send numerous collaterals to end among the cells of the ventral horn.

Rubro-spinal Tract (Bundle of Monakow). This tract runs down the lateral column ventro lateral to the cross pyramidal tract. It arises chiefly in the red nucleus of the opposite side, possibly also having some fibres from the red nucleus of the same side; the fibres and collaterals enter the dorsal part of the ventral horn.

Bulbo-spinal (olivo-spinal) Tract. This is a small tract in the cervical region, lying near the surface opposite the lateral angle of the anterior horn, which passes from the medulla oblongata to the olives.

B. ASCENDING TRACTS IN THE VENTRO LATERAL COLUMN.

The Direct or Dorsal Spino-Cerebellar Tract. This tract arises from the large cells of Clarke's Column of its own side. (Mott - Brain 1891-92, p.219). From these cells arise large fibres which pass to the peripheral and posterior margin of the lateral column of the same side, and ascend in the cord immediately anterior to the posterior incoming root fibres and lie just external to the cross pyramidal tract. They maintain this position till they reach the medulla where they are joined by a large bundle of fibres from the crossed inferior olive and then pass with them latero dorsally directly into the Restiform body and thence to the cerebellum. The tract increases in size as it ascends, the fibres having a rough lamellar arrangement(3) being successively displaced outwards by the incoming fibres higher up; so that in the cervical region the sacral fibres lie on the periphery of the spinal cord, and internal to them the lumbar, the thoracic, and most mesial, the cervical fibres. The ultimate termination of the fibres is somewhat uncertain, but there is no doubt that the cortex of the superior vermix is the chief end of the direct cerebellar tract.

The Ventral Spino-Cerebellar Tract. This tract arises in cells scattered throughout the grey matter chiefly of the posterior horn and intermediate grey matter of the opposite side. (4) (5) From these, fibres pass to the peripheral margin of the lateral column, occupying a position extending from the direct cerebellar tract behind, to the level of the anterior roots in front. The fibres which form this tract are finer than those which form the dorsal-cerebellar tract. It increases in size as it ascends the spinal cord; it continues directly on through the medulla oblongata, lying superficially, and is mesio-ventral to the spinal root of the fifth cranial nerve. It passes latero-dorsal to the inferior olive and is here mixed inextricably with fibres of the next tract (spino-thalamicus), and with Monakow's bundle (rubro-spinal), and with reticulo-spinal fibres. In the pons it becomes deeper at this level and is broken up into little bundles by fibres of the trapezal body; a few fibres separate and pass into the middle cerebellar peduncle of the same side and on into the cerebellum. It then passes posteriorly (dorsally) and hooks around the root fibres of the fifth nerve, to lie more and more superficially on the superior cerebellar peduncle, where it forms a white band of several white strands on the surface, which in

man may be easily seen by the naked eye. From there the bulk of the fibres pass to the valve of Vieussens to end in the ventral portion of the superior vermis.

The Spino-thalamic and Spino-tectal Tracts. These tracts arise from cells in the grey matter and pass by the anterior white commissure to the antero-lateral column of the opposite side. The Spino-thalamic fibres pass to the thalamus on the same side as the tract; associated with them are fibres which end in the mid-brain of the same side, but also slightly of the opposite side. They tend to lie mesial to the main bundles of Gower's Tract.

ANTERIOR COLUMN.

In this column there are fibres which arise from cells in the grey matter of the opposite side, mostly from the posterior horns and intermediate grey matter, and pass up from the ground bundle of the anterior column, some to terminate in the inferior olive, others being continued directly or indirectly to the optic thalamus on the same side.

POSTERIOR COLUMN.

These columns are composed mainly of ascending fibres which pass directly into the columns from the

posterior roots, a certain proportion of these fibres pass up the posterior columns to end in the posterior column nuclei - the nucleus gracilis and the nucleus cuneatus.

Fibres which enter the cord in the sacral region become displaced mesially by theadvent of each succeeding higher root, so that in the cervical region the sacral fibres are situated next the posterior median fissure and from within outwards there are arranged next to them the lumbar fibres, then the lower dorsal fibres, then the upper dorsal fibres, and then the cervical fibres - the latter being nearest the posterior horn. Below the fourth and fifth dorsal segment there is no division of the posterior columns, but above this level the posterior column is divided into a postero-internal tract (Tract of Goll), and a postero-external (Tract of Burdach) tract, by a thin septum of pia mater. The fibres passing in the postero-internal column end in the nucleus gracilis, the fibres in the postero-external ending in the nucleus cuneatus.

It is obvious that all the fibres that enter the posterior columns do not ascend to the posterior column nuclei. Many collaterals are given off, those from the fibres of the postero-internal column mainly to the lumbar enlargement, those from the postero-external column mainly to the cervical enlargement.

From the nuclei of Goll and Burdach the mesial fillet arises (medullo-thalamic path), and totally decussates, to pass into the ventro-lateral and central portion of the optic thalamus of the opposite side. On its way its gives branches to the opposite inferior olive, to the reticular formation, to the substantia nigra, to the anterior corpus quadrigeminum, and possibly to the posterior corpus quadrigeminum, but it does not give fibres (crossed or uncrossed) to the cerebellum, to the nucleus lentiformis, to the homo-lateral thalamus, nor direct fibres to the cortex.

SENSORY SYSTEM.

A BRIEF REVIEW OF THE SENSORY SYSTEM, SHEWING THE CHANGES WHICH TAKE PLACE IN THE GROUPING OF THE VARIOUS FORMS OF SENSIBILITY IN THE SPINAL CORD AS CONTRASTED WITH THEIR ARRANGEMENT IN THE PERIPHERAL NERVOUS SYSTEM.

BRIEF RESUMÉ OF THE SENSORY SYSTEM, SHEWING THE CHANGES WHICH TAKE PLACE IN THE GROUPING OF THE VARIOUS FORMS OF SENSIBILITY IN THE SPINAL CORD AS CONTRASTED WITH THEIR ARRANGEMENT IN THE PERIPHERAL NERVOUS SYSTEM.

Our knowledge of the sensory mechanism of the peripheral nervous system of the spinal cord and higher portions of the central nervous system has made great advances during recent years.(6) Head and those who have worked in association with him have furnished us with a new and more complete and co-ordinated idea of the sensory system as a whole. His investigations have been carried out by carefully observing the consequences of lesions of the peripheral and central nervous systems on sensory impulses in man. As a result he has furnished us with a more or less complete conception of the sensory mechanism from the periphery to the cortex. I propose to refer only to the results of his research on the sensory mechanism of the peripheral nervous system, and on the re-arrangement and transmission of sensory impulses in the spinal cord.

The work of Head and Rivers(7) and Head and Sherren(8) has brought out clearly that the peripheral afferent sensory

mechanism is made up of three systems:-

1. A system corresponding to the group of impulses known as deep sensibility. The end organs of this system respond to the stimulus of pressure and to the movement of joints, tendons and muscles. Painful impulses can also arise within this system as the result of injury to a joint or the application of excessive pressure. By this system there is also conveyed the appreciation of the locality of the stimulus and the direction of movement at any joint solely innervated by this system. The fibres which conduct these impulses run mainly with the nerves which supply the muscles, and are not destroyed by division of all the sensory nerves to the skin.

2. The protopathic system which responds to painful cutaneous stimuli and to the more extreme degrees of heat and cold. Its end organs are grouped in points on the surface of the body, sensitive to one only of these stimuli; their response to a stimulus is diffuse and not accompanied by any definite appreciation of the locality of the spot touched.

3. The epicritic system which conveys the impulses of cutaneous localisation, of discrimination of two points, and of recognising the finer grades of temperature called cool and warm.

This grouping of the afferent impulses in the peripheral nervous system was discovered by studying the consequences of division of the peripheral nerves and posterior roots in man.

Division of a cutaneous peripheral nerve causes loss of both epicritic and protopathic sensibility, but if reunion takes place there is first a restoration of protopathic, and later, of epicritic sensibility - that is to say that all the different forms of sensibility contained in the protopathic system return at one and the same time, and that with return of epicritic sensibility there is a restoration of all the forms of sensibility contained in the epicritic system. They further proved that the forms of sensibility included under the term "deep sensibility" were not destroyed by division of all the sensory cutaneous nerves, and that the fibres conveying these impulses run mainly with motor nerves. (Reference will be made later to the differences in the sensory loss which result from division of a posterior root as contrasted with a peripheral nerve.)

Head, working in conjunction with Thompson,[9] next investigated the grouping and transmission of the afferent impulses within the spinal cord, showing clearly that a re-arrangement of the grouping of sensory impulses took

place within the spinal cord.

For convenience it is best first of all to describe the effect of an intra-medullary lesion of the spinal cord upon each form of sensibility, and to contrast it with the effect of a lesion of the peripheral sensory system.

PAIN.

An intra-medullary lesion of the spinal cord, which affects the transmission of sensation to pain, causes insensibility to all forms of pain - cutaneous pain and deep pressure pain.

A peripheral lesion of the nerves or posterior roots, on the other hand, does not cause a loss of deep pressure pain, unless the deep sensibility as a whole is abolished.

HEAT AND COLD.

An intra-medullary lesion of the spinal cord, which affects the transmission of sensations of heat and cold, may cause:-

1. Insensibility to heat without loss of sensibility to cold.

2. Insensibility to cold without loss of sensibility to heat.

3. Insensibility to heat and cold.

Where sensibility to heat is lost there is loss to all degrees of heat, and when

sensibility to cold is lost there is loss to all degrees of cold. There is no dissociation of extreme or intermediate degrees of either heat or cold.

4. Insensibility to heat and cold may be absolute and yet the patient is able to recognise the lightest tactile stimulation, and to discriminate the two points of a compass.

A peripheral lesion of the nerves or posterior roots which causes destruction of epicritic and protopathic fibres interferes with afferent impulses for both heat and cold. After an injury protopathic sensibility recovers first, and at this stage the patient is sensitive to extreme degrees of thermal stimulation - below 20° C. and above 40° C. - but cannot discriminate between moderate degrees of temperature. In other words, there is no dissociation of heat and cold, but there may be dissociation of intermediate degrees of heat and cold from extreme degrees of heat and cold.

LIGHT TOUCH AND DEEP TOUCH.

An intra-medullary lesion of the spinal cord, which causes abolition of sensibility to touch on the opposite side of the body, causes affection of all forms of tactile sensibility.

In a peripheral lesion of the nerves or posterior roots, on the other hand, one of the most characteristic features is the frequency with which there is insensibility

to light touch, although deep touch and pressure are immediately recognised.

PASSIVE POSITION AND MOVEMENT.

An intra-medullary lesion of the spinal cord, which affects the transmission of impulses of Passive Position and movement, may cause:-

1. Loss of sensibility of passive position and movement without any loss of sensibility to all tactile and pressure stimuli.

2. Preservation of sensibility of passive position and movement with loss of sensibility to all other forms of sensation.

Sensibility of passive position and movement is therefore dissociated from the afferent impulses produced by pressure.

In a peripheral lesion of a nerve or posterior root a loss of sensibility to cutaneous stimuli may exist without any loss of sensibility to passive position or movement, but any loss of deep sensibility of pressure touch or pressure pain is always associated with loss of sensibility of passive position and movement.

THE COMPASS TEST.

Discrimination of two points of a compass applied simultaneously.

An intra-medullary lesion of the spinal cord may cause loss of power of discriminating two points without any loss of sensibility to light touch or tactile pressure. This loss is often associated with loss of the recognition of passive position and movement.

In a peripheral lesion of a nerve or posterior root sensibility to light touch is the first to be disturbed, and with it there is a depreciation of acuity to the compass test which may be taken as a measure of the acuity of cutaneous tactile sensibility.

THE GROUPING OF AFFERENT IMPULSES IN THEIR PASSAGE UP THE CORD.

PAIN, HEAT AND COLD.

The afferent impulses for pain, heat and cold cross to the opposite side of the cord and pass up in the lateral columns. They cross within three to five segments after their entrance, and in their passage up the cord they are clearly associated with each other, but each form of sensibility - pain, heat and cold - is

separate from the other, and the remote loss of sensation from an intra-medullary lesion may shew dissociated loss of any of these three forms of sensibility- all the impulses of that form of sensibility which is interferred with being abolished. The borders of the loss may correspond to those of intra-medullary segments, but more often merge gradually into parts of normal sensibility.

The impulses for pain, heat and cold pass up normally in the opposite lateral column to run up by long paths and short paths to the optic thalamus in the spino thalamic portion of Gowers' tract. If any fibres conveying impulses of pain, heat and cold pass up in Gowers' tract proper to reach the cerebellum, they convey unconscious impulses of pain, heat and cold. It is probable that there is a secondary path for the conduction of impulses of pain, heat and cold in the corresponding part of the homolateral column, which would explain the restoration of these forms of sensibility after hemisection of the cord.

TOUCH AND PRESSURE.

There is no evidence of dissociation of light touch, deep touch and the tactile element of pressure within the spinal cord, although if the borders of the

sensory loss are ill-defined, pressure can be appreciated over parts insensitive to cotton wool because of the greater tactile stimulus. The fibres conveying afferent impulses of touch and pressure cross to the opposite side of the spinal cord, but not so abruptly as in the case of pain, heat and cold. For one thing the peripheral paths conveying impulses of touch have a longer intra-spinal course, and further their passage to the opposite side of the cord is more oblique. They pass up the cord in the opposite anterior column. There is almost certainly a double path, or at any rate a potential double path, for the conduction of touch and pressure impulses, the crossed in the opposite anterior column, and the uncrossed in the homolateral posterior column. Division of both these tracts causes abolition of touch and pressure below the lesion. Of the two paths the crossed is the normal path, the uncrossed being subsidary.

PASSIVE POSITION AND MOVEMENT.

The fibres conveying the sensory impulses of passive position and movement pass up by the posterior columns on the same side.

DISCRIMINATION . OF TWO POINTS.

The fibres subserving this form of sensibility pass up the cord in the homolateral posterior column. This power of discriminating two points is distinct from tactile sensibility as it may be abolished in cases where there is no tactile loss, but on the other hand, a loss of tactile sensibility may cause a loss of the power of discrimination.

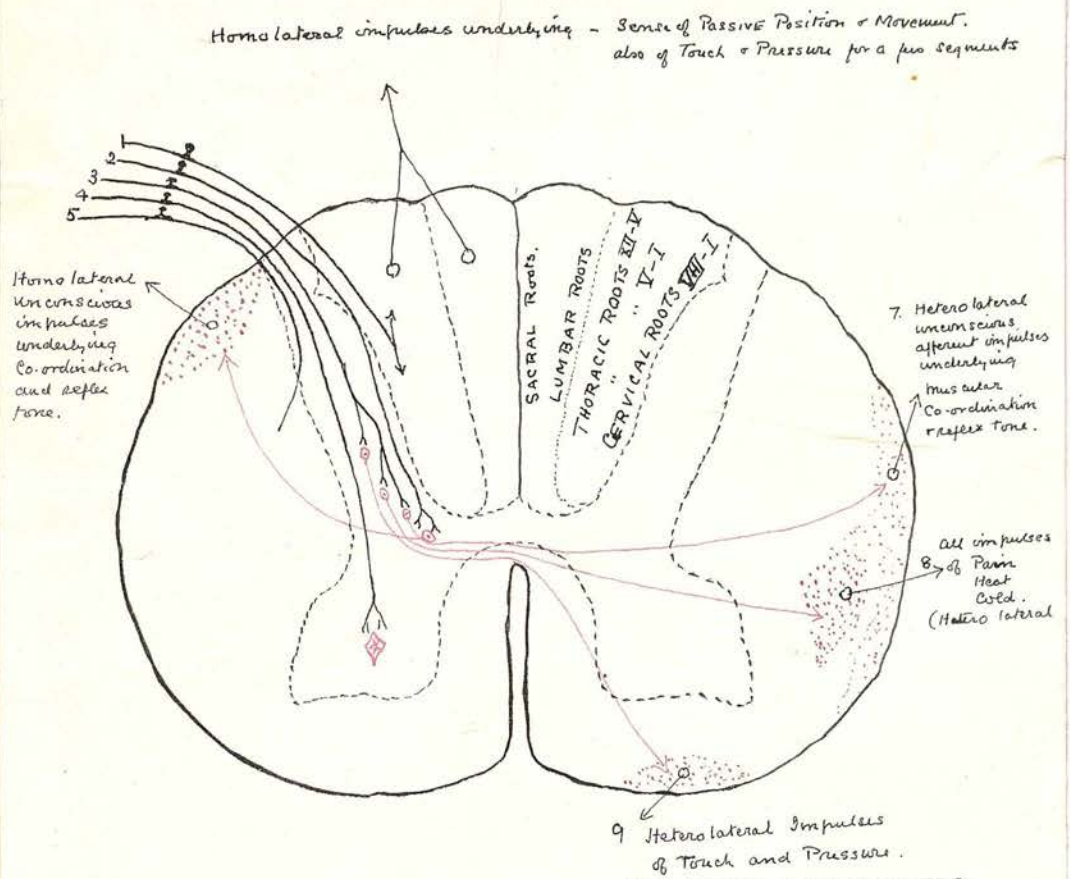


DIAGRAM to illustrate the TERMINATION of PERIPHERAL AFFERENT FIBRES in the Cord. and the origin of the SECONDARY PATHS.

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THE PRINCIPLES.

UNDERLYING THE PRODUCTION OF THE SYMPTOMS AND SIGNS OF COMPRESSION PARAPLEGIA.

A study of the signs and symptoms resulting from involvement of the Spinal Roots, Spinal Cord and spinal Column.

- Root Symptoms
  - Sensory
  - Motor
- Cord Symptoms
  - Ventro Lateral Columns
    - Motor
    - Sensory
    - Cerebellar Tracts
  - Posterior Columns
  - Central Regions of Cord.
    - Anterior Horns
    - Central Grey Matter.
- Spinal Column.
  - Bone Symptoms

ROOT SYMPTOMS.

I SENSORY - SUBJECTIVE. PAIN AND PARAESTHESIA.

PAIN.

Pain, one of the most important symptoms, arises as the result of pressure upon one or more posterior roots. The character of the pain may vary considerably in different cases and at different times in any one case, but two features are typical:-

1. The region to which the pain is referred is always the same although the pain itself may be inconstant and vary in its intensity and character.

2. The area in which the pain is complained of always corresponds to the sensory distribution of one or more posterior roots.

The Character of the Pain. It may present itself as a sharp stabbing pain, a sharp radiating pain, a dull aching pain, a burning pain, an unpleasantly painful numbness and tingling, or as a combination of all the above. Hyperaesthesia in the area affected by the pain is not common, but it does occur although it seldom continues for a long period.

The Constancy of the pain. It may be constant, intermittent, or continuous, although varying in intensity

from time to time. At first slight, it may increase or on the other hand at first severe, it may rapidly or gradually disappear; in some cases it is definitely paroxysmal; occasionally it may be very severe and after lasting for a shorter or longer period may completely disappear either permanently or to return some weeks or months later.

The explanation of this variation of intensity or remission of the pain is found in the majority of cases, in the causal factors present in each case. For example, if a root be involved in its passage through an intervertebral foramen pain may be brought on by movement of, or pressure on the affected portion of the spine, as occurs in some cases of caries or malignant disease of the spine. In other instances a root may be so related to a tumour that certain movements or postures cause pressure to be exerted upon it by the tumour. Continuous pain is probably due to the direct involvement of the root and its intensity varies directly with the rapidity of the growth.

Root pains may in time become less severe and ultimately cease, either because the pressure is removed from the root as occurs in some cases of spinal caries, or, as is more common, because of secondary degeneration

of the sensory fibres as a result of pressure. In the latter case a loss of sensibility may be detected in the area of distribution of the affected roots. The character of this sensory loss will be described later on.

In some cases pain persists although there is complete abolition of cutaneous sensibility in the affected area. In many cases, on the other hand, there is never any pain although the sensory roots may pass over or be attached to a tumour.

The posterior roots are more commonly involved by tumour than the anterior roots, and this may in part account for the frequency of pain as an early symptom, but it is obvious that pain will attract the patient's attention sooner than a slight degree of weakness or of muscular wasting.

PARAESTHESIA.

Paræsthesia apart from pain, is of rare occurrence but feelings of tightness, constriction and tingling are sometimes present as root symptoms.

Character of the Sensory Loss due to destruction of Posterior Roots. A loss of sensibility may result from the involvement of the posterior roots in their passage from the cord. It has been clearly proved

that division of one posterior root may not be attended by any discoverable sensory loss. This has been observed by most people who have studied this subject, and ample opportunity has been afforded for the investigation of this point by the examination of cases of spasticity which have been treated by "Forster's Operation" of posterior root section. In one patient of mine who was suffering from athetosis Mr. Armour divided the fifth and seventh Cervical and the first dorsal posterior roots on the affected side. No sensory loss could be detected. In some cases two consecutive posterior roots have been divided without any resulting insensibility; it is clear, therefore, that a given posterior root does not convey all the sensory impulses from its area of distribution.

The evidence of the character of the sensory loss from lesion of the posterior roots has therefore been based on cases in which several consecutive roots have been divided.

Division of posterior roots is followed by a loss of cutaneous sensibility both protopathic and epicritic. The area in which there is protopathic loss is larger than that in which there is epicritic loss. Within the boundaries of the area of protopathic loss there is a complete loss to cutaneous pain and to extreme degrees

of temperature - (below 15° C. and above 60° C.) Contained within the area of protopathic loss there is an area of epicritic loss, dimunition of sensibility to light touch and defect in the recognition of moderate degrees of temperature and in the discrimination of two points. The boundaries of this epicritic loss are not sharply defined and the severity of the loss is relatively less than that of the protopathic sensibility. In short "the unit of protopathic loss must be sought in one or more posterior roots". (8)

Sensory Loss after division of a Posterior Root. ((8))

"The nearer the lesion is situated to the posterior roots the more extensive and definite is the loss of protopathic sensibility; the more nearly the injury divides one of the nerve groups described above, such as the median, the ulnar, or the pre-axial nerves, the more definite and extensive is the epicritic loss. It would seem then as if each of these peripheral nerves, or nerve groups fromed a unit of the epicritic system; the protopathic unit must be sought in one or more posterior nerve roots.

This does not imply that division of a single posterior root would produce an area insensitive to protopathic stimuli, but sensitive to light touch and to the

minor degrees of heat and cold. For even from the protopathic aspect, fibres of any two posterior roots overlap one another especially on the limbs. But this overlapping is considerably less for the protopathic fibres of any one posterior root than for those which subserve epicritic sensibility".

Deep sensibility - deep touch, vibration, deep pain and sense of position - is not appreciably affected unless several consecutive roots are divided.

Sherrington[10] proved that sensory fibres run in the motor nerves and that these fibres pass from the motor nerves to enter the cord by the posterior roots.

The motor supply of any muscle or group of muscles is derived from several segments of the cord by fibres which pass from the cord by several anterior roots and later combine to form the motor nerve or nerves which end in the muscle.

Sensory fibres contained in these motor nerves convey afferent impulses of deep sensibility. These fibres eventually enter the cord by the posterior roots corresponding to the anterior roots from which the motor fibres composing the nerve are derived, Thus it is that the unit of deep sensibility is contained not in one or two, posterior roots, but in several.

In a number of the cases which I shall detail

later it will be noticed that there was sensory loss in the affected root areas. In a number of these the exact quality of the loss has not been fully investigated, but in Case the character of the sensory loss was definitely of the typical root type. The fact that division of the posterior root does not cause any appreciable sensory loss, whereas pressure on a spinal root may do so, would be hard to explain if it were possible to say definitely that in the latter case only the root was affected. In most cases where there has been clinical evidence of typical root sensory loss confined to one posterior root area, operation or post mortem examination has shown that although one root may have suffered severely the adjacent ones have also been affected by the lesion.

In other cases it is quite impossible to say that the lesion affected only the root because there may be definite evidence of pressure on the segment of the cord to which the root passes.

In some cases where there has been extensive lesion involving several consecutive posterior roots sensibility to deep pain, deep touch, sense of position and vibration have been lost.

TROPHIC CHANGES.

Trophic changes as the result of sensory root

lesions are not uncommon. The skin may become thin, glossy and dry, or thin and moist. Vasomotor changes occur, causing coldness, blueness, swelling and so on.

Herpes rarely occurs in cases of spinal tumour but may be met with in cases of caries or malignant diseases of the spine. A peculiar condition is sometimes present in the tissues surrounding the spine at the level of the lesion. The muscles are relaxed the subcutaneous tissues swollen. On palpation the tissues feel "boggy", suggesting the possibility of an abscess or local infiltration of the tissues. Yet on cutting into the part neither condition is found and it is probably due to interference with the local trophic influence.

II. MOTOR.

The motor symptoms which result from involvement of a motor root are weakness or paralysis, wasting and diminution or loss of electrical excitability whose chief innervation is supplied by the affected root. As a rule the first symptom to develop is loss of power, which after a short interval, is followed by wasting of the muscles. A stage may be arrived at in which the degree of power present in the limb appears to be in excess of the amount of wasting. When the affected muscles are those chiefly concerned in the performance of some

specialised movement the loss of function first attracts the patient's attention. In other cases the wasting of the muscles may be first noticed.

Finally paralysis may become almost complete with extensive wasting, but even then it is rare to find complete abolition of electrical excitability, the muscles still responding to the galvanic current.

Muscular paralysis and wasting are confined to the muscles supplied by the affected root. With the exception of the intercostal muscles, most muscles are innervated from three segments of the cord, the middle segment giving the major supply. In a root lesion, therefore, the muscular wasting and weakness are maximal in those muscles which receive their chief supply from the segment of the cord from which the root arises.

In rare cases the earliest symptom of involvement of a motor root may be irritative motor excitement in a nerve area, such as tremor, muscular tension or spasm.

Fibrillary tremor may sometimes be observed in the affected muscles, but personally I have only seen it in one case and I would regard its absence as characteristic of an anterior root lesion.

CORD: - SIGNS & SYMPTOMS.

VENTRO LATERAL COLUMNS.

MOTOR SYMPTOMS.

The lateral column contains the crossed pyramidal tract which conveys motor impulses from the opposite cerebral cortex. Pressure on the lateral column will therefore produce symptoms and signs of a lesion of the upper motor neurone, - spasticity and loss of power. These symptoms will be present on the homolateral side below the level of the lesion.

SYMPTOMS OF PRESSURE ON MOTOR TRACTS IN THE LATERAL COLUMN.

Reflex Spasms. The earliest symptom of on-coming paralysis may be the occurrence of spasms in the lower limb on the side of the lesion. The patient complains of "jumping of the leg" which occurs when he gets into bed at night, the leg suddenly draws up or if he inadvertently touches the leg with the other one it may cause it to jump and waken him. This reflex spasm

is usually flexor, but sometimes extensor; it may not be mentioned spontaneously by the patient, but in most cases if they are questioned on the point they acknowledge having noticed it before they were conscious of any weakness in the limb.

Weakness. The onset of weakness is in most cases gradual and is referred to the leg. The weakness is first noticed in walking; the leg "seems to become easily tired", to "drag" or to "feel heavy"; later the weakness becomes more obvious; he notices it not only in locomotion, but in other movements of the limb.

If spasticity be present he will complain of the leg and foot feeling stiff and of inability to prevent the toes scraping the ground.

In a certain number of cases the onset of weakness is first brought home to the patient by a sudden "giving way of the leg", which may cause him to fall. As a rule the leg recovers apparently completely, but these attacks of "giving way" become more frequent and permanent weakness gradually manifests itself. I have asked patients if, after "the leg gave way", they had noticed any weakness of the limb. Some say yes, others definitely assert no and state that they could move the leg

perfectly well and stand and walk on it quite comfortably when they had picked themselves up. I think, therefore that in many cases this sudden giving way of the leg is due to a reflex spasm. In no case do you find actual paralysis coming on suddenly without there having been previous signs and symptoms of motor weakness.

Sometimes the patient states that with the onset of weakness they noticed a numbness or tingling in the leg. I have never been able to investigate the cutaneous sensibility of a limb at this stage, and have failed to get a satisfactory answer from any patient I have questioned in regard to this. Some say that sensation was affected, but in no instance had the patient tested himself.

Sensory change may, however, be present in the opposite limb before the onset of motor weakness is noted. In these cases the loss of sensibility is to thermal and painful stimuli rather than to tactile. ( ) Batten's case

Hyper Tonicity and Spasticity. Reference has been made to the occurrence of flexor spasm in the leg. This is really an early manifestation of the increase in tone in the muscles, which may later become extremely

spastic and rigid from spastic contracture. Spasticity adds to the general loss of function in the limb and in some cases it is the spasticity rather than the weakness which prevents the patient from using the limb properly. It also causes contractures which may prevent voluntary movement or limit the range of such movement.

Spasticity is to a certain extent a guide as to the condition of the cord. In a total or even transverse lesion spasticity tends to disappear and be replaced by flaccidity and wasting. Thus in cases of spinal caries with compression of the cord a loss of spasticity without an improvement in power is a sign of further compression or softening of the cord. On the other hand the disappearance of spasticity with an increase in power is a most favourable sign.

This may be seen in cases of compression paraplegia where after the removal of the compressing agent the first sign of certain improvement is the diminution of the spasticity. In cases which have gone a stage further and have begun to become flaccid the return of spasticity is a favourable sign as all such cases have to retrace their steps through the spastic stage before the recovery is complete.

Muscular wasting. General wasting may result from a lateral column lesion, but is due more to the disuse of the affected limb than to any special local change. The wasting is not accompanied by any fibrillation or by any loss in electrical excitability.

In cases where there is a more complete lesion total transverse lesion, wasting is marked and rapid, with a change in the myotatic irritability in the muscles. When struck they contract sluggishly and bundles of fibres may stand out in slow contraction. The electrical reactions become changed. The faradic response is slow and diminished and the galvanic prolonged and feeble. The reaction of degeneration may not be present.

SENSORY.

The sensory symptoms of pressure on the lateral column are crossed. Below the level of the lesion there may be loss of pain, heat, cold and tactile sensibility. In the earlier stages of pressure there may be loss to pain, heat and cold without any tactile loss and in one case which I have seen since writing this paper, which Dr Batten is going to publish later, there was a loss to heat and cold without any other sensory loss and before there was any sign of motor weakness.

In one of my cases (Thomas Harris) when there was crossed sensory loss to pain, heat and cold, after removing the tumour that was a complete recovery of thermal sensibility with only partial recovery of painful sensibility.

Dissociated sensory loss may therefore result from pressure on the cord from without. Loss of tactile sensibility on the opposite side below the level of the lesion is frequently seen as a result of pressure on the lateral column, but it may not be absolute as some impulses may pass up the homolateral posterior column and in order to produce a complete loss of tactile sensibility on the opposite side it would be necessary to destroy the opposite ventro lateral column and the homolateral column.

CEREBELLAR TRACTS.

Pressure on these tracts causes ataxia of the cerebellar type. It is distinguished from the ataxia due to pressure on the posterior columns in that there is neither loss of sense of position nor any impairment of discrimination of compass points. The ataxia is more pronounced on the side of the lesion, but there may be some affection of the other leg as well; it is uncommon for ataxia to be present as a result of pressure on the cord without a considerable degree of motor weakness as the pyramidal tract is closely associated with it in its passage down the lateral column.

POSTERIOR COLUMNS.

The symptoms of pressure on a posterior column are ataxia, loss of sense of position and loss of discrimination of compass points.

ATAXIA AND LOSS OF SENSE OF POSITION.

The ataxia is similar to that which is seen in tabes and is due to a loss of sense of position; it is rare for the ataxia to be the sole cause of the para-

plegia in cases of tumour, as in the majority of cases where the posterior columns are most affected the lateral columns also suffer a certain amount of motor weakness. In some cases, however, the loss of sense of position may be the chief factor which affects the patient's gait.

In Case there was a cyst in the dorso median fissure which compressed both posterior columns causing loss of sense of position in both lower extremities and well-marked Rombergism.

DISCRIMINATION OF COMPASS POINTS.

Associated with loss of sense of position there may be found an inability to discriminate two points. The combination of loss of sense of position and discrimination of two points is not uncommon in intra-medullary lesions.

In Case in which the tumour compressed the postero-lateral aspect of the cord there was loss of sense of position and of discrimination of compass points on the same side as the tumour. Unfortunately this form of sensibility has not been tested in the great majority of cases.

Central Regions of the Cord.

Anterior Horns,,,,It may occasionally happen that an extra medullary lesion causes destruction of the anterior horns, the symptoms resulting from this are atrophic paralysis and loss of the electrical reactions in the muscles supplied by the affected segment; they are therefore similar to those produced by lesions of the anterior roots.

Central Regions of the Cord. Destruction of the central portions of the cord are characterised chiefly by dissociated sensory loss as the lesion destroys the fibres which pass in the anterior and posterior commissures conveying different forms of sensibility to the opposite side of the cord. As the fibres subserving sensibility to pain, heat and cold cross more abruptly than those conveying tactile impressions; there may be a local loss to pain heat and cold in areas in which tactile sensibility is intact. In some cases there may be dissociation of pain from heat and cold or indeed of any one of these forms of sensibility. Probably the loss of sensibility to heat and cold is greater than the loss to pain although it is practically impossible to verify this clinical fact by pathological investigation.

BONE: - SYMPTOMS & SIGNS OF DISEASE OF THE SPINE.

The importance of careful and systematic examination of the spine in all cases of paraplegia cannot be over estimated. On it may depend the diagnosis of the cause of the paraplegia and the decision as to the subsequent line of treatment to be adopted. For example if a case of spinal tumour is diagnosed wrongly as a case of spinal caries, much valuable time may be lost - on the other hand failure to recognise a case of caries may entail serious consequences to the patient.

Disease of the spine may or may not be attended with pain, but in most cases the objective examination will reveal some abnormality. The family history and the previous history and health of the patient should be enquired into as regards tubercular and malignant disease. A history of injury is often mentioned by the patient; it may not have any bearing on the patient's condition; on the other hand if it be associated with a tubercular history it should not be lightly dismissed.

PAIN.

Pain is a common symptom in disease of the spinal column. It varies in its character and situation, but three distinct types can be recognised.

(1) Pain due to pressure upon the Posterior Roots.

The character of root pain has been already described under Root Symptoms. The involvement of the roots may be directly due to the spinal condition. When this is so the following features may be present: -

(a) Movements of the spine or certain postures excite pain;

(b) Local pressure on the spine excites pain;

(c) Deformity of the spine at a level corresponding to the root pain.

These features cannot, however, be taken as more than presumptive evidence as all of them may be present in cases of intra-thecal tumour, nor on the other hand does their absence exclude the possibility of bone disease.

(2) Pain due to local disease of the bone.

This pain is gnawing in character and is confined to the affected portion of the spine and its

immediate neighbourhood, its distribution, therefore, does not correspond to that of any root or sensory nerve and it is never associated with sensory loss. It may be continuous or intermittent. When it is intermittent it is usual to find that the exciting cause is pressure upon the affected portion of the spine. Many patients, for instance, are unable to lie on their backs or to rest against a chair on account of the pain, and are obliged in order to obtain rest, to lie on one or the other side, or to sit in a chair with their back supported by cushions.

(3) Pain due to Muscular Strain induced by Spinal Weakness.

This pain is dull and aching in character and is referred to the spinal muscles, often at some distance from the seat of local disease. It commences gradually and increases in severity as the patient becomes tired - it is relieved by rest, change of posture and rubbing of the spinal muscles.

From what has been already written, it may be gathered that posture and movement often play an important part in exciting pain in cases of spinal disease,

but a diagnosis of spinal disease as the sole cause of the pain should never be made without most careful examination, not only of the spine itself, but of the nervous system.

THE EXAMINATION OF THE SPINE.

I do not intend to enter into a full description of a systematic examination of the spine, but merely to indicate the lines upon which such an examination should be made. All irregularities, deformity, curvature or enlargement of the bones should be noted. If curvature be present that due to posture or some general condition must be distinguished from that due to local disease of the spine. Having inspected the spine the physician should next palpate it in order to discover whether there is any local tenderness, and if such exist, whether it corresponds to any local deformity of the spine or to the level of the nervous lesion. He must proceed to test the mobility of the spine and note the presence of rigidity or absence of normal movement. He may discover that movement of certain parts of the spine causes pain or signs of nerve irritation. Every case should be carefully investigated for signs of

abscess, tubercular or malignant disease in the glands, viscera, and other bones of the body. Wherever possible X-ray photographs of the spine should be taken, not only of the apparent seat of the spinal disease but also of that region of the spine which corresponds to the level of the nervous lesion.

Radiography may yield valuable positive information; more often the result is negative, but none the less helpful on that account. It must always be remembered that some obscure condition may affect the spine. A case is on record in which paraplegia was due to an aneurism which had eroded the bodies of the vertebræ and pressed upon the cord. Laminectomy was performed and the aneurism mistaken for a growth with disastrous result. Such mistakes can always be guarded against by means of radiography.

NATURE AND SITE OF THE LESION IN RELATION TO ITS PHYSICAL EFFECTS ON THE SPINAL CORD AND ROOTS.

NATURE AND SITE OF THE LESION IN RELATION TO ITS PHYSICAL EFFECTS ON THE SPINAL CORD AND ROOTS.

There is no doubt that the clinical symptoms and signs of compression paraplegia vary to a large extent according to the nature and site of the extra medullary lesion. Before entering into any detailed description of the effects of pressure upon the individual spinal paths I will consider seriatim the various effects of different extra medullary lesions.

I. INTRA-THECAL.

A. LEPTO MENINGES.

a. Chronic Lepto Meningitis - simple thickening.

A generalised thickening of the lepto-meninges may not produce any effect on the cord at all, and it is not until the lesion affects the peripheral circulation of the cord or exerts pressure upon it that any symptoms arise. In many cases vascular and meningeal changes develop at the same time, although quite independent one of the other. The symptoms are therefore very indefinite and wide spread without showing any definite level. In such cases a slight degree of spastic weakness may be present, with sphincter trouble and sensations of

numbness and tingling, but without any detectable sensory loss.

Where there is compression of the cord, owing to the lepto-meninges becoming specially thickened at one level, localising symptoms may be found. Below the lesion there is a bilateral spastic weakness of gradual onset - the degree of weakness is greater than any above the level should such be present. If the compression be in the lower mid-dorsal region, as is common in such cases, the superficial abdominal reflexes will be present above, and absent at and below the level of the lesion. Sensory loss may develop later, and is usually incomplete and bilateral, and corresponds to the level of the change in the abdominal reflexes. The local symptoms may be indefinite and wide spread, as the meningeal thickening may compress the cord over several successive segments. They are recognised by a greater degree of sensory loss approaching the root type and motor weakness in the parts supplied by the affected segments as compared with the remote paralysis and sensory loss seen in the parts innervated from the cord below the level of the lesion. Root pain is very rare although girdle sensations are not uncommon. The roots do not as a rule shew obvious change although sometimes they appear small. The cord

does not become softened, it may be shrunken and small; but pulsates normally.

The exceptions to the above description are found in cases of syphilitic meningitis, which is often associated with vascular changes in the superficial and deep vessels of the cord. It may give rise to meningo myelitis, a slow form of myelitis from thrombosis, and local softenings of the cord may result. Clinically these cases tend to approach the Brown Sequard type of paralysis.

b. Chronic Lepto-Meningitis with adhesions and damming up of Cerebro Spinal Fluid.

In these cases the cerebro spinal fluid may become dammed up at one point; on opening the spinal canal three conditions may be found:-

1. The dura may be constricted at one point and distended above it, pulsation being visible above but absent below the constriction.

2. The dura may not shew any change but on opening it the arachnoid is found adherent to the cord above which it is at one level distended with cerebro spinal fluid.

3. There may be a localised collection of fluid within the arachnoid, (the so called arachnoid cyst.)

There is little tendency for softening of the cord to ensue in these cases. When the constriction is

circular there are signs and symptoms of compression of the whole cord at a definite level - Bilateral spastic weakness, changes in the reflexes, sphincter trouble and sensory loss below the level of the lesion. Where there is an arachnoid cyst the pressure may be exerted only on one surface of the cord, giving rise to corresponding symptoms and signs.

B. LEPTO AND PACHY MENINGES.

a. Chronic Lepto and Pachy Meningitis.

In this type of lesion there may be damming up of cerebro spinal fluid and constriction of the cord or interference with its vascular supply. It is generally syphilitic in origin and is frequently found in cases of cerebro spinal syphilis and meningo myelitis. The meningeal changes may be present only in the spinal membranes but the cerebral membranes are often similarly and simultaneously affected. The symptoms may be wide spread and diffuse, but those due to compression of the cord are, in the early stages local such as girdle sensation, pain, numbness and tingling; these are followed later by remote spinal pressure symptoms and spastic weakness, sphincter trouble and sensory loss. Sometimes one side of the cord is more affected than another, but the tendency is for the development of a complete trans-

verse lesion. The symptoms, sub-acute in onset may suddenly become acute.

C. PACHY MENINGES.

a. Chronic Pachy Meningitis.

It might be thought that this condition, which is generally of syphilitic origin, would be bilateral affecting both sides of the cord, but in its early stages it is usually unilateral: it gradually extends and eventually surrounds the cord. The spinal roots are first involved and may be degenerated before any symptoms of pressure on the cord are noticed. The earliest symptom is root pain, followed later by sensory loss in the area of distribution of the affected roots and motor palsy of the lower motor neurone type. It is rare for one root alone, more commonly two or three adjacent roots on one side are involved. On the other hand roots on both sides of the cord may be affected early with corresponding symptoms.

There is no doubt that the condition eventually tends to spread so as to surround the cord and cause a circular compression, but often the thickened dura becomes adherent to the lepto meninges and cord on one aspect and by interfering with the vascular supply

causes a sclerosis or softening of that portion of the cord, and thus gives rise, clinically, to a Brown Sequard type of paralysis in association with local root symptoms.

D. INTRA-THECAL TUMOURS.

a. Circumscribed.

When the tumour is firm and circumscribed, such as a fibro sarcoma, neuro fibroma or endothelioma, it usually arises either from the membranes or in connection with the spinal roots, especially the posterior. Its growth is slow and when it compresses the cord it causes first an indentation of the surface against which it impinges. There is no softening of the cord, only a simple atrophy similar to that which is seen in the pons in cases of extra cerebellar tumour. Later, often much later, a degree of general compression of the cord between the tumour and the theca may take place; softening rarely occurs, although long continued pressure may cause it by interfering with the vascular supply. The symptoms therefore are:-

1. Root symptoms - pain, sensory loss, muscular weakness and wasting - on the same side as the tumour, present only of course if the roots are involved.

2. Symptoms of pressure on the same side of the cord i.e. spastic weakness on the same side and sensory loss on the opposite side below the level of the lesion.

3. At a much later date bilateral spastic weakness and sensory loss with sphincter trouble.

When the tumour is diffuse the tendency is for it to spread round the cord and compress the roots. Growths of this type may be malignant and tend to infiltrate the cord or to cause softening. Unless the growth infiltrates the cord unilateral cord symptoms are uncommon. It is not unusual for such growths almost completely to surround the cord without causing any local compression. Pressure only becomes exerted upon the cord when the growth fills up the space between it and the theca; it is then general. Clinically the root symptoms are more diffuse and wide spread than in the case of circumscribed tumours. The cord symptoms if at first unilateral rapidly become bilateral. Tumours of this character are not uncommon in the sacral region and may first involve the cauda equina, spreading up later to surround and compress the cord.

II. EXTRA-THECAL.

Lesions which are extra-thecal and cause pressure on the cord, may be entirely separate from the theca,

or on the other hand, may implicate and involve it and even extend within it to invade the cord.

a. Extra thecal lesions which do not invade the theca.

The spinal cord may be compressed by a tumour or other abnormal condition situated in the perithecal space; in these cases there may be root symptoms quite early in the history of the case due to pressure. Symptoms of pressure on the cord will not arise as long as there is room for it to be displaced, and as it is comparatively loosely attached to the walls of the vertebral canal considerable displacement is possible before it becomes compressed between the tumour and the opposite side of the vertebral canal. If the tumour be slow growing there will be a gradual onset of symptoms indicating pressure on both sides of the cord; if, on the other hand, the tumour be of rapid growth there is only a short interval between the onset of the paraplegic symptoms and the development of signs of a more or less complete transverse lesion. This is sometimes well seen in cases of caries, where the formation of an abscess within the vertebral canal is rapidly followed by the sudden onset of severe paraplegia.

b. Extra thecal lesions which invade the theca.

When the theca is involved by the extra medullary

lesion there is more likelihood of one aspect of the cord being compressed before the occurence of general compression. This may be due simply to the fact that the cord cannot escape from the intra-thecal pressure or may be accounted for by the extension of the growth or lesion through the theca and lepto meninges.

c. Extra Thecal pressure from disease of the Spinal column.

Pressure may be exerted upon the spinal cord by the extension into the vertebral canal of disease or growth; apart from this any acute displacement of the vertebral bodies may cause a certain degree of stretching of the spinal cord and lead to a slow process of mal-nutrition and, eventually, a certain amount of degeneration and sclerosis. Such stretching must be long continued before any evidence of affection of the spinal cord is noticed, and such effects are only observed when the lesion occurs in adult life. It is practically unknown in cases of spinal deformity developing in the earlier years of life, unless the deformity is associated with some lesion of the intra-vertebral canal.

SIGNS AND SYMPTOMS
IN RELATION TO THE LEVEL OF THE LESION.

SIGNS AND SYMPTOMS IN RELATION TO THE LEVEL OF THE LESION.

I have already dealt with the character of the various symptoms & signs from the point of view of their origin & have described the features of those due to involvement of the spinal roots, spinal cord & spinal column. In analysing the clinical features of the various types of compression paraplegia I shall deal more especially with the symptoms, their distribution & mode of onset, from the point of view of the diagnosis of the nature of the lesion & its situation in relation to the cord; & I shall not attempt to enter into the localisation of the level of the lesion as to do so would involve much repetition & conplicate the discussion of the cases.

I have thought it best therefore to devote a special chapter to the consideration of the symptoms & signs according to the level of the lesion, & to complete the survey of the symptomatologyfrom the general point of view.

THE LOCALISATION OF THE LEVEL OF THE LESION.

The level of an extra-medullary lesion causing compressing of the spinal cord may be determined by

(1) The local signs - Those due to the local effect of the lesion on the spine, spinal roots or cord.

(2) The remote signs - Those which result from interference with the conducting paths in the cord.

LOCAL SIGNS AND SYMPTOMS

Spine. Deformity, rigidity, pain on movement or pressure may all be of value in the determining the level of the lesion, if however, they do not correspond to the level indicated by the nervous symptoms and signs they must not be relied upon as guides to the level of the spinal compression but rather as indications that the primary lesion is one which involves the spine.

In spinal caries for instance the cord lesion is due to pressure from some extension of the disease into the vertebral canal which may occur at one level unattended by any local signs of caries, while at another level where there are obvious signs of spinal disease, such as prominence and tenderness of the spine,

angular curvature or abscess formation, the disease has not extended into the canal and, therefore, not caused any spinal symptoms at this level.

SPINAL ROOTS. In many cases of spinal compression the extra-medullary lesion involves the roots. Root symptoms may therefore, precede the spinal symptoms, or both may develop together. Speaking generally it may be said that the level of the root symptoms is the level at which the cord is compressed, although it may not correspond with the remote sensory loss the upper border of which may only extend to a segmental level some segments lower than that of the lesion. It may occasionally happen that a tumour which involves a root at one level may compress the cord at another level owing to its greatest dimension being situated not at its point of origin but some distance from it. This should not, however, influence one in deciding as to the region to be explored when laminectomy is to be undertaken, as the tumour must extend from the level of the root lesion. It might make

the diagnosis of the condition difficult by simulating the symptoms and signs of syringo myelia. If, for example a tumour originating on the 8th. cervical root on one side extended upwards to cause compression of the cord at the level of the 5th. cervical segment, the local signs followed by an upward extension of cord symptoms might be mistaken for syringo myelia as in this disease the growth often extends up the cord.

SPINAL CORD. Local cord symptoms have a distribution similar to that of their corresponding roots.

MOTOR. Local motor cord symptoms can only arise from an extra-medullary lesion when the pressure exerted by the tumour affects the cord by causing a transverse lesion and destruction of the anterior cornual cells. The muscular paralysis resulting will be of the lower motor neurone type with wasting, loss of the deep reflexes and diminution of electrical excitability. It will be present on both sides and the evidence that it is due to an intra-medullary lesion and not to a bi-lateral root lesion will be furnished by an increase in the remote motor

and sensory paralysis, with an absence of root pain on the side opposite the tumour.

SENSORY. The sensory disturbance following a local lesion of the cord is most severe in the area of distribution of the posterior roots corresponding to the segment or segments affected. Owing to the peripheral overlap a small lesion may be attended with very little defect of sensibility.

REFLEXES.-- Each segment of the cord contains certain reflex centres. A stimulus entering by a posterior root fibre may be transmitted to the motor cells of the corresponding or adjacent segments by means of collaterals, which are given off either from the primary division of the sensory fibre in the cord , or which arise from processes originating in a nerve cell with which the peripheral fibre is connected. A characteristic sign therefore of a root or local cord lesion may be the abolition of certain reflexes.

REMOTE SIGNS AND SYMPTOMS.

REMOTE MOTOR SIGNS.-- Interference with the pyramidal tracts is followed by paresis or paralysis of the muscles innervated from below the level of the compression. This paresis is of the spastic type & is not accompanied by local wasting or change in the electrical reactions. The innervation of the muscles from each spinal segment has been fully worked out & when the highest level of the motor paralysis has been ascertained it only remains in order to determine the level of the lesion to observe the segmental distribution with which the upper limit of the paralysis corresponds. This is easily ascertained in cases where the paralysis affects the limbs but is more difficult when the lesion is in the dorsal region causing paralysis of the abdominal & trunk muscles. In order to detect the level of the paralysis in these cases the patient should be made to lie flat on his back with his arms folded on his chest, & told to raise his head or to attempt to sit up. If the lower abdominal muscles are paralysed the umbilicus will be drawn upwards by the non-paralysed portion. The converse also holds good if, as the result of a peripheral lesion, the upper

abdominal muscles are paralysed.

In cases where the local cord lesion becomes a total transverse one the motor paralysis changes from the spastic type to the flaccid & there is a gradual loss of all the deep reflexes & wasting of the muscles. These changes however are not due to the greater severity of the pyramidal lesion but to other factors involved.

The following table gives the chief motor supply from each segment of the spinal cord.

MOTOR LOCALISATION IN THE SPINAL CORD.

TABLE SHOWING THE PRINCIPAL MUSCLES AND THEIR SPINAL REPRESENTATIONS.

C 2-3 Deep muscles of the neck, trapezius, sterno-mastoid.

C 3 Levator anguli scapulæ, trapezius, sterno-mastoid, diaphragm scaleni.

C 4 Diaphragm, trapezius, levator anguli scapulæ, scaleni, rhomboids, deltoid, spinati, biceps, supinator longus.

C 5 Deltoid, spinati, teres minor, rhomboids, diaphragm, biceps, supinator longus, serratus magnus, pectoralis major, brachialis anticus, coraco-brachialis.

C 6 Biceps, coraco-brachialis, brachialis anticus, supinator longus, deltoid, spinati, teres major, serratus magnus, pectoralis major, subscapularis, pronators, extensors of wrist.

C 7 Triceps, extensors of wrist and fingers, pronators, pectoralis major, subscapularis, latissimus dorsi, teres major.

C 8 Flexors of wrist and long flexors of fingers, interossei, lumbricales, thenar and hypothenar muscles.

D 1 Muscles of Thenar and hypothenar eminences, interossei, lumbricales, flexor carpi ulnaris, oculo-pupillary fibres.

D2-12 Intercostals, rectus abdominis, serratus posticus, internal and external obliques.

L 1-2 Ilio-psoas, quadratus lumborum, sartorius, cremaster, quadriceps.

L 3 Quadriceps, sartorius, quadratus lumborum, adductores, obdurator externus.

L 4 Adductores, quadriceps, sartorius, tensor fasciæ femoris, tibialis anticus, extensor communis, extensor hallucis.

L 5 Tibialis anticus, extensor communis digitorum extensor hallucis, peronei, abductors and external rotators of hip, gastrocnemii, flexor longus digitorum, hamstrings, glutei.

S 1 Gastrocnemii, hamstrings, long flexors of toes, peronei abductors and external rotators of hip, glutei.

S 2 Glutei, intrinsic muscles of foot, gastrocnemii, hamstrings, long flexors of toes.

S 3-5 Muscles of perinæum connected with defæcation, micturition, erection, ejaculation.

Note. Underlining indicates the principal supply of each segment.

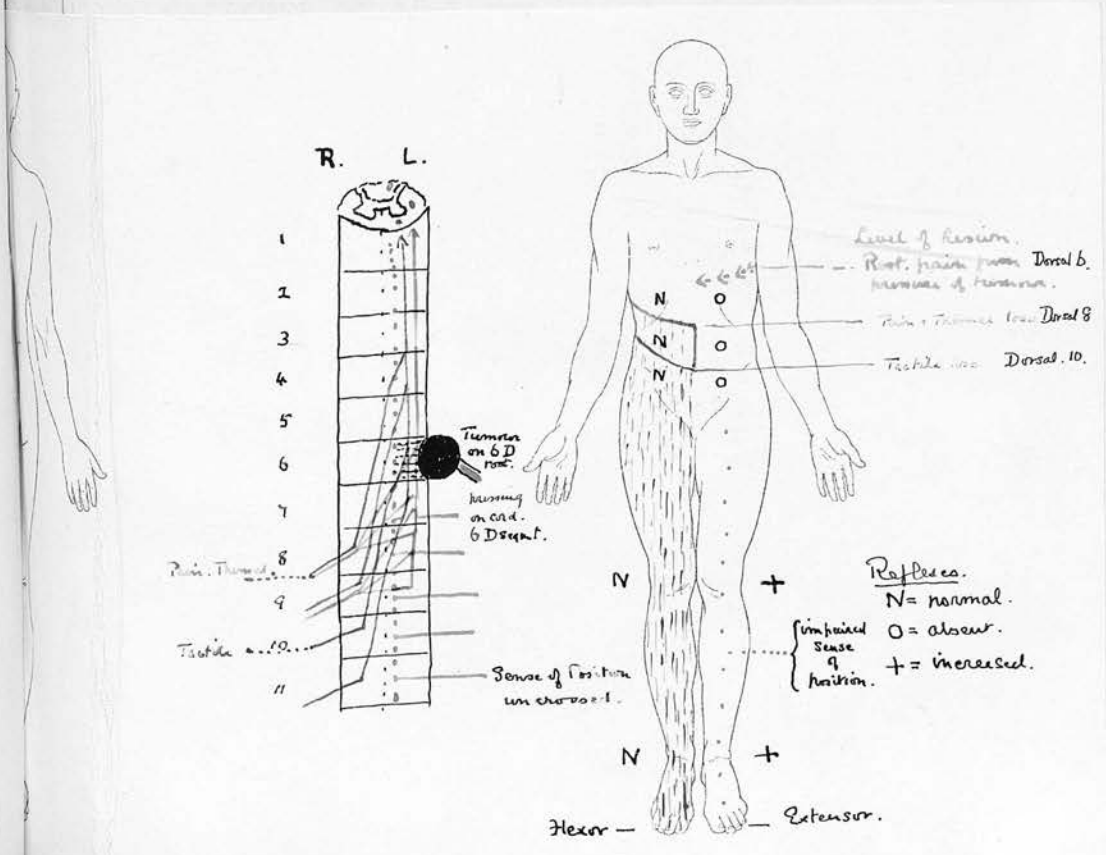
REMOTE SENSORY SIGNS AND SYMPTOMS.-- There is no doubt that interference with the sensory paths may give rise to various subjective sensations. Some of these are due to irritation-- pain, formication, etc.-- others to the cutting off of certain impulses, which permits those which can still pass to obtrude unduly on the patient's consciousness. These sensations will all be referred to portions of the body below the level of the lesion, but they form no guide as to the level: for example, a patient with a lesion in the upper dorsal region may complain of numbness in one foot. It is necessary therefore to rely upon the examination of the patient & the detection of sensory loss in order to ascertain the level of the compression.

A complete transverse lesion causes abolition of sensibility below the level of the lesion, almost complete loss at the level of the lesion, & slight impairment immediately above it. The reason the sensibility above the level of the lesion is impaired & that that at the level of the lesion is not completely abolished is that there is an overlap in the areas of distribution of the peripheral fibres entering by the posterior roots. This is shown in the accompanying diagram.

In all cases therefore in which there is a transverse lesion the highest level of the sensory loss must be taken as the guide to the level of the spinal segment affected. When there is a complete transverse lesion this level is easily detected, but in slighter cases the greatest care must be taken in mapping out the upper border as the sensory loss will only be relative.

An incomplete transverse lesion may cause interference with the sensory paths on one side of the cord only or indeed of only certain paths. In these cases the resulting sensory loss will be below the level of the lesion & its upper border may be situated at a level which does not apparently correspond to that of the lesion. Failure to recognise this fact has often led to faulty localisation. The explanation of this phenomenon is found in the fact that certain forms of sensibility are conveyed up the cord on the side opposite to that on which they enter, & that they do not all cross at the same level. Impulses of pain & thermal sensibility cross soon after their entry, tactile more obliquely. Thus, a lesion on one side of the cord will only cause loss of sensibility of those forms which have already crossed. As an example we may take

a case in which a tumour grew from the left sixth dorsal posterior root & compressed the left half of the cord at the level of the sixth dorsal segment. On the left side the patient had root pain in the distribution of the sixth dorsal posterior root & spastic weakness of the lower limb with increase in the deep reflexes, abolition of the superficial abdominal reflexes on the left side, & an extensor response on stimulation of the sole of the left foot. He also had loss of sense of position in the left leg. On the right side there was no weakness & the reflexes were normal, but there was loss of sensibility to pain, heat, cold, & light touch. The upper border of



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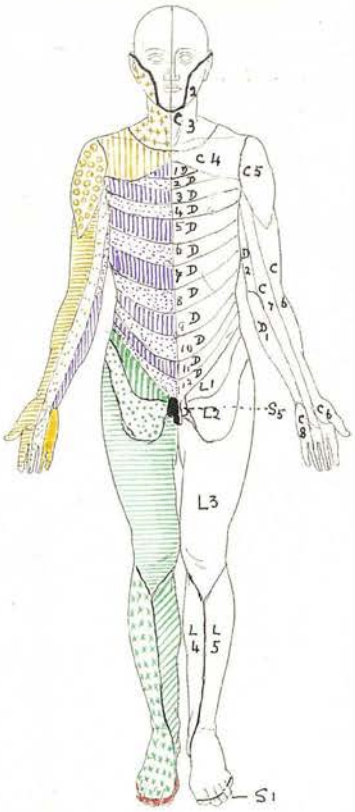
In some cases there may be dissociated sensory loss, i.e., pain, heat, cold, or touch may be impaired or lost independently of each other. This may be observed in cases of extra-medullary compression, as a rule in cases which simulate the Brown-Sequard symptom-complex. This dissociated loss may be an early symptom or on the other hand it may be noted as a passing phase during recovery after the removal of pressure. It must not therefore be taken as implying an intra-medullary lesion to the exclusion of an extra-medullary, for although it is a sign of interference with the sensory paths within the cord it does not necessarily signify an actual destruction of these paths.

In cases of compression paraplegia, especially when the lesion is situated in the cervical or upper dorsal regions it is not uncommon to find that sensibility is retained in the lowest sacral & lumbar areas. This, I think, is best explained on the assumption that the paths conveying sensibility from these areas lie nearer the centre of the cord as they pass up from the caudal end. In a small number of cases the converse is seen, but only when a severe central lesion exists at the site of the compression.

SEGMENTAL SENSORY LOCALISATION.-- The segmental sensory areas have been worked out by many neurologists, who have published diagrammatic schemes. The scheme which I reproduce has been compiled from the observation of cases at Queen Square in which the situation of the lesion has been determined by operation or post mortem examination. I have for several years devoted special attention to this subject, & although my diagram does not correspond in all details to those already published it is, I think, more accurate. In the reports of the cases I have furnished charts showing the sensory loss. It will be seen that they correspond closely to the scheme now given.

DIAGRAM of SENSORY SEGMENTAL AREAS.

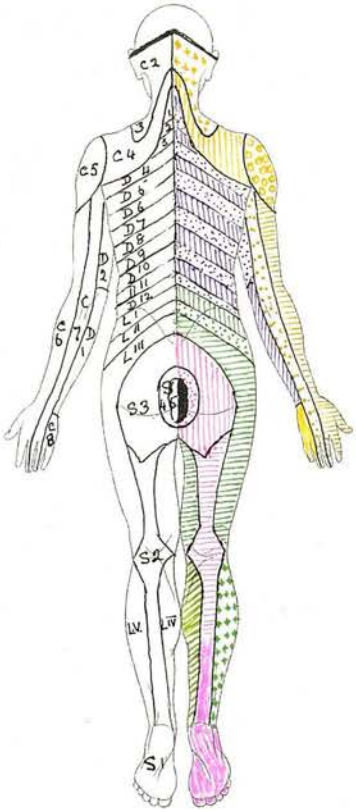


Cervical Segments. yellow.

Dorsal Segments. purple

Lumbar Segments. green

Sacral Segments. red. except the 5th sacral area which is indicated in black.



The 5th Sacral Segmental area is indicated in black

REFLEXES.-- Reference has already been made to the effect which a local lesion may have on any reflex which depends on the integrity of a simple reflex arc for its production, but I have not entered into a discussion of the remote effects arising from the spinal lesion. The pyramidal tracts have a very intimate relationship with the deep reflexes. This influence is probably exerted on the anterior horn cells & is of an inhibitory nature, although the whole matter is not yet fully understood. A lesion of the pyramidal tracts is followed by an increase in the deep reflexes below the level of the lesion. This is certainly the case in all cases of slow compression. When one side of the cord is compressed an increase in the deep reflexes of the same side is observed. Loss of the deep reflexes never results from a pyramidal lesion, but may follow any interruption of the primary arc or a total transverse lesion of the cord. Certain other reflexes are closely associated with the pyramidal tract, viz., the plantar reflexes & the superficial epigastric & abdominal reflexes. The change in the planter reflex can be watched throughout in cases of slow compression. At first it is flexor, then indefinite, then extensor when the outer side of

the foot is stimulated, & finally extensor from stimulation of any part of the sole. It is always the last reflex to be lost in complete transverse lesions. The superficial epigastric & abdominal reflexes have their primary arcs in the dorsal segments of the cord from the fifth to the twelfth. A pyramidal lesion above any of these segments will cause abolition of the reflexes below the level. The changes which occur in these reflexes are very definite, & as they are the earliest sign of pyramidal involvement are of the utmost value in localising the side of the lesion & in some cases its level. The earliest change is ready exhaustion, later an obvious diminution, & finally abolition.

If in a case of spinal tumour these reflexes are absent on the right side the tumour must be situated on the right side of the cord above the level of the fifth dorsal segment, & if there is no weakness of the right upper limb it must be somewhere between the first & fifth dorsal segments. Similarly, if the lesion is at the level of the tenth dorsal segment the reflexes will be present above the umbilicus but absent below.

The cremasteric reflex is not affected by pyramidal lesions.

CRANIAL NERVES.

It is most unusual to have cranial nerve symptoms associated with compression paraplegia, and as a rule their occurrence is explained by the presence of more than one lesion. In spinal tumour cases, for example, there may be an intra-cranial tumour as well, the commonest instance is multiple neuro fibroma or fibro sarcomata, several such cases are on record (13.) and one of mine (68.) had a tumour on the fifth cranial nerve and one on the second cervical root. I have seen two cases of choroidal tumour growing in the fourth ventricle with metastatic growths (11.) inside and outside the cord, and Barnes (12) has described a case of sarcoma which spread in a similar manner. These cases however are easily recognised. Syphilitic spinal meningitis may be associated with syphilitic affections of the cranial nerves such as oculo-motor palsy, inequality of the pupils, absence or diminution of the pupillary light reflex. Such symptoms however are in no wise due to the spinal lesion and are of value only in so far as they are an outward manifestation of a syphilitic infection.

Optic Neuritis. Optic Neuritis has been observed in a few cases of spinal tumour and spinal caries when the lesion was situated in the upper cervical region. It was present in Case (68), but although I am of opinion that it was due to the high situation of the spinal tumour in this case (2nd Cervical - medulla) I

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cannot over-look the fact that there was a small tumour situated on the 5th cranial nerve on the right side. I once observed neuritis in a case of high cervical caries with pressure on the upper cervical cord. Taylor and Collier (14.) described the occurrence of optic neuritis in cases of cervical and high dorsal lesions - injury, tumour and myelitis. Of these three were tumours, one situated at the level of the 3rd Cervical segment and two at the level of the 5th; and they also report a case of Nonne's in which a tumour was situated at the third cervical segment. The explanation of the occurrence of optic neuritis in these cases remains to be solved whether it is due to increased intra-cranial pressure owing to damming up of the cerebro spinal fluid at a level which offers no chance of escape by the lymph channels in the posterior roots, or whether to some local upset of the nervous mechanism in that portion of the cord.

Oculo-motor Nerves. The only oculo-motor sign which I have seen in association with spinal tumour has been nystagmus. It is never so definite as that seen in cases of cerebellar disease or disseminated sclerosis but its occurrence is worthy of notice because its presence has on one or two occasions led to a diagnosis of disseminated sclerosis being made in the early stages of cases of spinal tumour.

Cervical Sympathetic symptoms. These arise as the result of irritation or destruction of the upper three dorsal roots. It is remarkable how seldom these symptoms are present considering the number of cases in which the lesion is situated at that level. Probably the fibres are not affected in slowly progressive lesions. In one of my cases a pachy meningitis (77), irritative cervical sympathetic symptoms were very prominent, but then the lesion was sub-acute. Congestion of the optic disc on the same side as the cervical sympathetic lesion has been noticed in a few cases, but the appearance of the disc never extends beyond that seen in the earliest stages of true neuritis.

Respiratory Symptoms. Respiratory movements are carried on by the diaphragm and intercostal muscles: of these the diaphragm is much the more important. It is supplied by fibres which arise from the third, fourth and fifth cervical segments, but even in cases in which the lesion is situated above this level diaphragmatic action may persist although the inter-costal muscles are completely paralysed(29). This can only be explained by the assumption that the fibres innervating the diaphragm are more resistant to pressure than those which supply the intercostal muscles. Lesions below the fourth cervical segment may completely abolish intercostal action without causing much respiratory embarrassment. Lesions above the fourth cervical, especially when they

cause severe compression, are attended by respiratory difficulty the patient making use of the accessory muscles of respiration.

Cardiac Symptoms. Accelerator fibres pass from the region of the floor of the fourth ventricle to enter the cardiac plexus by the sympathetic system, they emerge from the cord in the root of the fourth to the ninth dorsal segments. Irritation of these fibres causes a marked rise in the pulse rate. This is not often observed in cases of spinal compression but it is certainly one of the causes of death in cases of laminectomy in the upper dorsal region.

Paralysis of these fibres may induce a distinct slowing of the pulse rate, but here again chronic conditions do not appear to exercise much effect.

Vasomotor Symptoms. In long standing cases of compression there is constriction of the vessels; the skin in the paralysed part becomes dry and scaly, the limbs pale and cold. In acute lesions or when a chronic lesion becomes acute signs of vaso-dilatation appear, the paralysed parts lose their pallor and a slight degree of oedema develops which is often attended by the rapid formation of bed sores.

Visceral Symptoms.

Intestinal. The onset of acute paraplegia may cause paralytic dilatation of the gut, a symptom which is always ominous.

Sweat Glands. Compression of the cord may impair the action of the sweat glands not only may the paralysed parts appear dry, but injection of pilo carpine fails to cause any sweating in areas below the level of the compression. This has been employed by Horsley as a method for mapping out the level of the lesion. I have frequently made use of this test, in some cases the line of demarcation is definite but in the majority the result is disappointing.

Bladder and Rectum. The centres for the control of the bladder and rectum are situated in the lower sacral segments. A complete transverse lesion at this level or involvement of the corresponding spinal roots causes loss of sensation in the bladder and rectum, with loss of control. The urine tends to dribble away without any distension of the bladder, constipation is usually present but if any purgative be administered defaecation takes place quite unknown to the patient. The tone of the sphincters is always abolished in these cases. A unilateral lesion of the roots or cord, however, does not cause any permanent impairment of the sphincter control. Compression of the cord above the level of the lumbar enlargement is not attended by any sphincter trouble, provided that the pyramidal system is affected only on one side. Whenever signe of bilateral lesion appear there is first of all some difficulty in passing water or in severe cases retention with overflow.

Later there is incontinence, the urine being voided at irregular intervals; in this stage there is no distension of the bladder but on the other hand it is never properly emptied so that there is a great danger of infection from contamination of the residual urine.

Priapism. Priapism does not often occur in complete transverse lesions but is occasionally observed in cases of partial compression especially of the upper dorsal cord.

Trophic Changes. As a general rule compression of the cord does not cause excessive trophic change below the level of the lesion unless it is so severe as to cause a condition approximating to a total transverse lesion. When this occurs bed sores appear to follow almost without provocation, not being confined to regions affected by pressure.

SPINAL CARIES. TUBERCULAR DISEASE OF THE SPINE.

PATHOLOGY.

The disease may originate in the bodies of the vertebræ, in the laminæ, or in the ligaments and periarticular structures. Most commonly it arises in the body of the vertebra near its articulation, where it forms a small area of softening due to the necrosis and breaking down of the boney tissue. This focus may develop into a caseous mass or become purulent and form an abscess: if the disease is extensive destruction of the vertebræ causes a local collapse of the spine and the formation of an angular curvature.

When abscess formation occurs the abscess may extend downwards along the bodies of the vertebræ underneath the anterior common ligament and pass thence to form a Psoas abscess. In disease situated higher than the mid dorsal the abscess may extend into the mediastinum. In cervical caries the abscess may be retro pharyngeal, or extend posteriorly and appear in the neck. In lower dorsal and lumbar cases, lumbar abscess is common while in sacral cases the abscess forms deep in the buttock. On the other hand, the ~~pus~~ disease may pass backwards round the bodies of the vertebræ where its further progress is obstructed by the posterior common ligament, which diverts it into the neural canal where it appears as a reddish

swelling composed of tubercular granulation tissue, caseous material or pus. Such abscesses may exert pressure on the cord by displacing it against the vertebral arches, or the tubercular process may extend and invade the meninges either surrounding the cord or binding it down to the bodies of the vertebræ.

Tubercular disease frequently affects the roots by causing collapse of the spine and pressure on them as they pass through the intervertebral foramina or they may be involved in a tubercular pachy meningitis. The cord may be affected by simple pressure, or by meningeal compression and obstruction of the blood vessels and lymph paths. This latter gives rise to œdema of the cord which is followed in long standing cases by the development of a secondary sclerosis.

Schmaus (15) considers that œdema of the cord may possibly be due to the action of an associated toxic condition. A true tubercular myelitis due to the local action of tubercle within the cord may occur although very infrequently. One such case which came under my notice was published by Turner and Collier.

Relative frequency of the disease in the different regions of the spine.

The dorsal and lumbar regions are most frequently affected and the cervical region more often than the sacral. The disease often involves two adjacent vertebræ and may be multiple. Tubercular disease of the spine may be a primary condition but is often associated with scrofula or general tuberculosis.

ETIOLOGY.

Heredity. An hereditary predisposition to tubercular disease is sometimes present but more often there is a history of tubercle in the family. One member having contracted tubercular disease may infect other members from close contact and association with them.

Age. Caries occurs most commonly in children its frequency lessens with age, after 35 it becomes rare, although it may occur at any age.

Sex. Boys and girls are equally affected, but in adult cases men are more frequently affected than women, probably because they are more exposed to strain and injury.

EXCITING CAUSE.

Injury, exposure or privation are often responsible for the onset of the disease. (cases 1 & 2.)

SYMPTOMATOLOGY.

GENERAL.

Constitutional Symptoms. In early cases there may be no constitutional symptoms but in long standing cases or in cases where the caries is but one manifestation of a general tubercular condition they are invariably present. Fever may or may not be present.

Bone Symptoms. Bone symptoms and signs are usually present in cases of Spinal Caries, which give rise to compression of the cord. In looking through the records of the cases admitted to the National Hospital - cases in which paraplegia or root symptoms were present, in only one was there no external evidence or tenderness on pressure.

1. Pain in the region of the diseased vertebra may or may not be constant but is aggravated by movement or by pressure. Tenderness on pressure is often limited to one or two spinous processes, and

is increased by deep pressure - percussion - or local movement. It can be distinguished from the tenderness present in hysterical cases by the fact that in the latter pain is elicited by slight or deep pressure - or not elicited should the patient's attention be distracted, the tenderness is not limited to one spot and may be present on pressure over the muscles away from the spine. Another test which is sometimes useful is the Hot sponge test - A hot sponge passed over the spine causes pain as it is passed over the affected vertebræ. Personally in all the cases in which I have found this present there was an area of hyperæsthesia - and I have found this test positive in cases of spinal tumour. I therefore regard it as indicating hyperæsthesia rather than disease of the spine, but I have not had the opportunity of applying it to cases in which there were no signs of root or cord affection.

2. Rigidity. Pain may cause the patient to keep the affected portion of the spine rigid; this is often an early sign of great importance. Rigidity may also be due to ankylosis of the spine but in such cases there is evidence of spinal deformity.

3. Deformity. This may take the form of an undue prominence of one or more spinous processes which are tender on pressure or of kyphosis with true angular curvature a condition almost pathognomonic of caries if injury can be excluded.

3. Secondary Abscesses. These may be the first signs of spinal caries and may form outside the spinal canal. They may be situated behind the pharynx, in the neck, in the lumbar region, under the Psoas muscle or deep in the buttock. In such cases deformity and spinal cord and root symptoms may be absent though as a rule when the disease has advanced sufficiently for the formation of such abscesses, it gives rise to local signs and symptoms. Abscesses may form in the spinal canal, the first symptoms being those of spinal compression or in rare cases a root lesion may be involved with root pain, and occasionally herpes.

An analysis of 32 cases of paraplegia due to spinal caries shews that the first symptom was referred to the spine in 16 cases, to the roots in 12, and to the cord in 4, and that in 16 cases root symptoms were absent. It also shews that of the 16 cases in which spine symptoms developed first the cord was next affected in 12

cases, the roots in 4; of the 12 cases in which root symptoms developed first - cord symptoms followed next in 8, spine symptoms in 4.

Root Symptoms. It is characteristic of the root symptoms of spinal caries that in the early stages they are brought on by movement or the adoption of certain postures. This may cause the patient to keep the affected portion of the spine more or less rigid. Herpes is occasionally present in these cases, and therefore care should always be taken to exclude local bone disease before coming to the conclusion that any case is simply one of ordinary "shingles". In caries also neuritis may be present and this and the herpes lends support to the idea of a toxic inflammatory condition playing some part in the production of the peripheral symptoms.

Cord Symptoms. When these are the first to arise they are due to the invasion of the vertebral canal by tubercular inflammatory material or abscess, the symptoms may point to affection of one side of the cord but more often to an affection of both. When the disease is chronic or subacute the local extension is slow, with the formation of adhesions to or local involvement of the dura on its anterior aspect. This

causes clinically a slow onset of bilateral spastic paraplegia which slowly progresses to finally terminate in a more or less rapid onset of signs of complete transverse lesion. If there is an acute abscess the onset and progress of the cord symptoms is very rapid, signs of a complete transverse lesion developing within two or three weeks.

When the cord symptoms are secondary to root symptoms they may at first be of the Brown Sequard type but it is rare for this to persist for long and as a rule both sides of the cord are soon affected. In this, caries resembles cases of diffuse malignant sarcoma and is quite different from the cases of circumscribed intra thecal tumours. When symptoms of pressure on one side of the cord persist, they are evidence of local meningeal thickening and adherence to the cord on one aspect.

MOTOR.

The motor symptoms are spastic paralysis with increase of the deep reflexes, extensor plantar responses and loss of the superficial abdominal reflexes. It has been already mentioned that there may be rapid onset of total paraplegia. It is equally astonishing to see the rapid recovery which may follow on removing the local

disease from around the cord - cases which clinically would lead one to suppose that there had been actual destruction of the cord at the time of the lesion recovering rapidly. This points to a functional disturbance greatly in excess of the organic changes present, and pathological examination bears this out. There is a local œdema of the cord with swelling of the sheaths and axis cylinders - this may abolish function without destroying the axis cylinder. It is remarkable how little descending and ascending degeneration is present in these acute cases (16.) on the other hand secondary degeneration may be well marked in long standing cases in which the cord has become sclerosed at the seat of compression.

SENSORY.

Hyperæsthesia above the level of the lesion is relatively common and more or less characteristic. It points to a condition more acute than simple compression approaching more to the type of an infective myelitis. As already mentioned, I think this hyperæsthesia is largely responsible for the reaction to the hot sponge test.

Local sensory loss corresponding to the segments involved is somtimes very characteristic and may provide evidence of the existence of more than one focus of disease. (Cases III & IV)

Remote sensory loss. Similar to that which occurs in cases of Brown Sèquard paralysis is sometimes noted but only when the lesion is meningeal and chronic.* In most cases all forms of sensibility are blunted below the level of the lesion, though frequently the sacral areas are relatively less affected,× especially where lesion is high up.

* Case V

× Case VI & Case VII

SPHINCTERS.

As a rule there is at first retention or difficulty in passing water which is followed later by incontinence associated with constipation and a loss of control over the rectal sphincters after the administration of purgatives.

SARCOMA OF THE SPINE.

Sarcoma or osteo sarcoma may develop as a primary condition or may be secondary to sarcoma elsewhere. It tends to be more localised than carcinoma and to grow more slowly. Where it is secondary it is more malignant spreading rapidly.

Sarcoma may spread into the vertebral canal without invading the spine, but in these cases evidence of the primary seat of the growth is usually present, such as glandular enlargement, mediastinal growths, etc. In this section I am only dealing with cases in which the spine is involved.

ETIOLOGY.

Sex. Both sexes are equally affected.

Age. Sarcoma may occur at any age. It differs from carcinoma in being more common in childhood and puberty and early adult life than in the later years.

SYMPTOMATOLOGY.

Spine. Bone symptoms and signs.

Pain. Pain of a dull gnawing character referred to one portion of the spine is an early symptom; it may

gradually become more severe. Objective signs may be absent for a long time and then develope more or less rapidly. The affected part becomes tender and swollen. On palpation the swelling feels nodular or boggy and often extends into the surrounding tissues simulating a deep-seated abscess and is tender on pressure. In cases of sacral sarcoma the condition may appear very local or one-sided and may suggest tubercular disease of the ileo sacral region but although pain is elicited by direct pressure on the swelling, lateral compression of iliac bones may cause no discomfort.

Root Symptoms. Root symptoms are as a rule early and may be present before there is any obvious alteration in the bones. One or more roots may be involved and in the early stages they are on the same side and usually consecutive. The pain may remain limited to the areas of these roots and then suddenly another root becomes affected. Several roots on one side may be involved before any on the other side and the roots first affected may be destroyed and degenerated before fresh roots are affected. Thus it is common to find loss of sensibility of the root type in the areas when the pain was first felt with intact sensibility in areas which the pain has lately invaded. In some cases as the root degenerates the pain ceases but often it may

persist despite the complete loss of cutaneous sensibility. The motor roots suffer as well as the sensory, there is great weakness in the muscles and later wasting with loss of the deep reflexes and diminished electrical reactions. It is characteristic of these cases that motor and sensory paralysis are always associated.

Cord Symptoms. In the vast majority of cases cord symptoms are late in appearance. The exceptions being cases in which the growth is sub-periosteal and has directly invaded the perithecal space without causing any destruction of the vertebral bodies or pressure on the roots. This occurs chiefly in cases of osteo-sarcoma when the tumour is of slow growth. Pressure is first exerted on the anterior or antero-lateral aspect of the cord - the symptoms corresponding to pressure on that region, to which may be added later, motor or sensory root symptoms. These symptoms slowly increase and then suddenly there is a rapid onset of signs of a transverse lesion and sometimes of posterior root symptoms, a slight degree of paraplegia becoming total within four to five days. When the growth passes into the perithecal space through the intervertebral foramina there is a combination of root symptoms with those of compression of the cord chiefly on the side of the tumour.

If the growth invade from the right side - there will be root symptoms on the right side - muscular weakness and wasting with sensory loss - and below the level of the root symptoms spastic paralysis with increased deep reflexes and extensor response and perhaps loss of sense of position; on the left side there may be loss to pain, heat and cold and tactile sensibility, without loss of sense of position and without motor weakness, the reflexes remaining normal.

Sarcoma of the Sacrum may involve the lower sacral roots causing first pain and later loss of sensation in, and paralysis of , the bladder and rectum. It may simulate sacral tabes but is distinguished from it by the absence of other signs of tabes and by the examination of the cerebro-spinal fluid. In tabes sensibility to pain is often diminished without appreciable loss to touch, the change is bilateral, the border of the loss being ill defined whereas in sarcoma of the sacrum the loss is of the root type often unilateral and with a sharp border.

CARCINOMA OF THE SPINAL COLUMN.

Carcinoma of the spine is invariably secondary. The seat of the primary disease is in the majority of cases the breast, but it may be in the stomach, intestines, rectum, uterus, prostate, lungs, kidneys, suprarenals or thyroid. Of eleven cases which were examined post mortem at Queen Square, 5 were secondary to breast cancer, 3 to cancer in the lung, 2 to cancer in the kidney, 1 to cancer in the liver, and 1 to cancer in the rectum.

Some time ago I made some enquiries as to the interval which might elapse between the removal of a mammary carcinoma and the development of secondary disease in the spine. I found that it might be as short as 6 months that in the great majority of cases it was between 18 months and 5 years that in a considerable number it was 6 - 8 years and in one private case of my own it was 15 years.

The disease may infiltrate one or two vertebræ or be more or less generalised throughout the spinal column and often affects the ribs or pelvic bones. It leads to softening and necrosis of the vertebræ which may col-

lapse and cause deformity, prominence or angular kyphosis. In certain cases the growth invades the vertebral canal before the spine becomes affected by passing in between the laminæ or along the nerve roots. Once inside the vertebral canal it may surround the theca and so compress the cord or it may pass in along the roots invading the theca and lepto meninges and finally the cord itself. Indeed it is not uncommon to find the roots and cord affected without any considerable tumour lying within the vertebral canal or theca. The invasion of the cord by way of the roots causes obstruction of the blood and lymph vessels and œdema and softening of the cord from interference with the circulation. This or the breaking down of tumour tissue which has invaded the cord sometimes leads to the formation of cavities within the cord.

It is possible that there is also a local toxic action, but of this there is no proof.

"Neuritis" is said to occur in some cases; the clinical ~~epitome~~ symptoms support this. In one of my cases in which the sacral and lumbo-sacral nerves were affected the clinical evidence of neuritis was quite definite.

The clinical aspect of these cases varies in the certain stages according to the way in which the disease spreads. If the spine be involved first then bone symptoms are early, root and cord symptoms are later.

If the growth passes into the vertebral canal root and cord symptoms are present before there are obvious signs of involvement of the spine.

ETIOLOGY.

Sex. Men and women are both affected. But the disease is much more common in women than in men, the proportion being about 3 to 1. This is due almost entirely to the fact that the breast is the most common seat of the primary disease. If cases occurring after 55 are taken, the number of men and women affected is about equal.

Age. Carcinoma of the spine is uncommon before middle age, the majority of cases occurring after 40. Cases do occur earlier, especially those secondary to disease in the thyroid and lungs.

SYMPTOMATOLOGY.

General. In many cases constitutional symptoms are marked. The patient is cachectic looking, wasted, with a lemon-tinged complexion. These symptoms may not however be prominent during the early stages, but carcinoma of the spine should always be suspected when a

patient who has previously had an operation for carcinoma or who is suffering from carcinoma, develops pain in the back, especially if in addition there are symptoms or signs of pressure on the spinal roots or on the cord.

Bone Symptoms. The earliest symptom may be pain in the spine, often of a deep gnawing character, at first intermittent, later becoming more constant. Examination may not reveal any abnormality, but as time goes on the affected vertebræ become tender on pressure and later some prominence of the spines may be observed. The patient may now be unable to rest if he lies on his back owing to the pain which any pressure excites. Not infrequently there is a rather sudden development of kyphosis, which is distinctly angular. This is due to destruction of the bodies of some of the vertebræ. In other cases the disease invades the whole of the spine without causing any local deformity. A general affection of the spinal column may take place without any root or cord symptoms, but when an angular curvature develops, root and cord symptoms soon appear. On the other hand root and cord symptoms are often present before there is any sign of disease of the spinal column.

Root Symptoms. Root symptoms occur early when the growth invades the spine through the inter-vertebral foramina. First there is root pain followed by weakness, sensory loss and muscular wasting. These may be the only symptoms present for several weeks or even months.

Cord Symptoms. The onset of signs and symptoms of pressure on the Cord is almost always preceded by bone or root symptoms, or by both. It is sudden and there is a rapid development of signs of a total transverse lesion. In most cases the clinical signs point to a transverse lesion from the outset, the exceptions being cases in which the growth has passed along the roots, especially the posterior roots to infiltrate the cord, but even in these instances the lesion soon becomes total. Death occurs very rapidly owing to the patients general condition and the occurrence of bed sores and septic infection.

EXTRA-THECAL: - HYDATIDS.

A rare cause of perithecal pressure is the invasion of the vertebral canal by hydatid cysts. When this occurs they have usually entered the canal either from the intra-peritoneal, or thoracic region. They may cause great erosion , either of the vertebræ or of the laminæ, and sometimes cause deformity and curvature.

SYMPTOMATOLOGY.

Local symptoms due to involvement of the spine are almost always present in the shape of pain of a dull aching character. This may be associated with tenderness on pressure or on percussion over the spine.

Root symptoms may or may not be present. When they do occur they follow immediately upon the bone symptoms.

Cord symptoms may develop somewhat insidiously, but usually become rapidly acute with signs of a complete transverse lesion. Unless there is a previous history of an echinococcal infection, the condition may not be recognised, but all the patients whom I have seen

had a most peculiar muddy complexion. They all complained of pain in the back, they all had tenderness on pressure. X-ray examination may reveal erosion of the vertebræ, and some cases have been diagnosed by puncture of the cyst.

Operative treatment. The removal of the cysts by operative treatment, if done early, before the compression of the cord has become acute, may be followed by a complete recovery. On the other hand should the symptoms of transverse lesion have developed, the recovery is slow and incomplete. In three of five cases which were operated on at Queen's Square, there was a recurrence. In one of these a second operation resulted in a recovery which was complete and has been permanent for seven years. (23)

EXTRA DURAL TUMOURS: - THECAL & PERI-THECAL.

PATHOLOGY.

In this group I have collected all the cases in which the tumour lay in the peri-thecal space: I have included some in which the tumour grew from the dura, but did not infiltrate it so as to appear on its inner aspect. I have excluded cases of malignant disease of the spine in which there was a direct extension of the growth within the vertebral canal. I have described separately 5 cases in which hydatid cysts were found pressing on the cord.

The commonest forms of extra dural tumour are sarcoma, fibro-sarcoma, endothelioma, psammoma; and lipomata sometimes occur. The majority of the peri-thecal tumours, excluding tumours of the spine itself, arise from the theca or in connection with the roots which have been affected by the direct extension of an extra-spinal growth through the inter-vertebral foramina.

Of the 18 cases which I have collected the tumours were 5 fibro-sarcomas, 6 sarcomas, 3 endotheliomas, 1 carcinoma, 1 in which the nature of the growth was doubtful.

LOCALITY.

Of the 16 cases of extra thecal tumour six were mid dorsal, 4 in the lower dorsal region, 4 in cervico-dorsal region and two in the upper cervical region.

ETIOLOGY.

Age. The age incidence of these tumours varies according to their nature. Fibro-sarcoma and endothelioma commonly arise between the age of 30 and 50, but may occur in quite young people.

Lympho- or round-celled sarcomas occur chiefly about the age of puberty. Of the 6 cases in my series one occurred at 10, 2 at 15, 1 at 16, 1 at 31, 1 at 36.

Sex. Fibro-sarcoma is rather more common in males than in females.

Endothelioma more common in males.

Sarcoma occurs with equal frequency in either sex.

Injury does not appear to play any part in the production of the tumour.

SYMPTOMATOLOGY. SLOW GROWING TUMOURS.

Mode of Onset. Except in the cases of rapidly growing sarcoma which I shall describe separately, the symptoms show great similarity. In a number of cases the earliest symptom is pain in the spine, in others root pain, while in the remainder the cord symptoms developed first.

Spine. Symptoms and signs. Pain in the back referred to the region of the tumour is complained of in some cases, but as a rule this symptom was merely temporary. Tenderness on pressure sometimes occurs, but is infrequent. Deformity of the spine at the level of the lesion is extremely rare.

Root symptoms are not common, but are occasionally present. When this is the case they may be the only symptom for a long period.

Cord Symptoms and signs of pressure on the cord sometimes point to pressure exerted on one side of the cord only, in these cases the tumour is always attached to the theca and approaches, both pathologically and clinically, cases of intra-thecal tumour. It is more usual to have either a slow onset of weakness in both

lower extremities or a relatively rapid onset accompanied by sphincter trouble and sensory loss.

The points of distinction between the slow growing extra thecal and the slow growing intra thecal tumours are shown in the following table:-

	Extra-thecal.	Intra-thecal.
Bone	Tenderness on Pressure more common.	Tenderness on pressure rare.
Root.	Rare. When present are long continued without cord symptoms.	Not uncommon; may be long continued without cord symptoms but usually associated with unilateral cord symptoms.
Cord.	When present are usually bilateral from the commencement and may be slowly progressive or rapid. Dissociated sensory loss uncommon.	Except in the cases where the tumour is anterior or posterior they are first unilateral and at a much later period bilateral. Dissociated sensory loss more common.

RAPIDLY GROWING & DIFFUSE PERITHECAL TUMOURS

PATHOLOGY.

Tumours falling under this category consist of the more malignant types of sarcoma and carcinoma. Sarcoma may be primary, but is more often secondary and invades the perithecal space by extending through the intra vertebral foramina or between the laminæ. The roots are always involved, at first on one side, shortly after on the other. The growth may affect one side of the cord before the other, but more commonly it surrounds the cord and exerts pressure on both sides. Its action on the cord is very rapid and there is a great tendency for the tumour to extend within the dura and to pass along the posterior roots, spreading out over the surface of the cord and infiltrating it along the peripheral vessels.

SYMPTOMATOLOGY.

Bone symptoms. Local pain and tenderness is often complained of. In some cases the primary growth is situated in the posterior mediastinum, and may possibly

cause a certain amount of local pain quite apart from the perithecal growth. There is also a tendency for the spine to be invaded which may of itself cause pain.

Root. Root pains are always present, at first unilateral they rapidly become bilateral and may extend both up and down from the point of origin.

Spinal Cord Symptoms. Unilateral symptoms are uncommon and when present are never of very long duration, being rapidly followed by symptoms of a transverse lesion of the cord which soon becomes total with loss of the deep reflexes, flaccid paralysis and complete sensory loss. When the tumour is primarily perithecal it is less malignant and the clinical picture is more like that of a fibro-sarcoma or endothelioma. In 2 cases (H. Spicer and F. Stansfeld) there was well marked dissociated sensory loss, the former after operation, and the latter before operation. In one case (S. Davis) of Endothelioma at the level of the 6th dorsal segment, the sensory loss was most marked over the sacral and lower lumbar areas, the converse of what is usually seen when there is an inequality in the degree of sensory loss below the lesion.

INTRA THECAL TUMOURS: - INTRA THECAL AND EXTRA MEDULLARY.

I have based my description of the clinical signs and symptoms ~~in these cases~~ on a study of 20 cases.

These cases may be divided into two groups, one in which the tumours are firm and circumscribed, the other in which the tumours are diffuse and not circumscribed.

CIRCUMSCRIBED INTRA THECAL TUMOURS.

PATHOLOGY.

The tumours in this group are either fibrosarcomas, neuro-fibromas, endotheliomas or psammomas. They are as a general rule single, the chief exception being in the case of neuro-fibromas, which may affect cranial and spine nerve roots and are often multiple.

In one of my cases (68) there was an extra-cerebellar tumour on the 5th cranial nerve, and in another case (67.) there were two distinct spinal tumours. They arise from or are attached to the inner aspect of the theca, the arachnoid, the nerve

roots, or the pia mater. At first they are generally circular in shape, but tend to become elongated and cylindrical or sausage-shaped and to extend up and down the cord parallel to it, thus compressing the same aspect of the cord in the whole of their length. They may lie posterior or anterior, but more commonly are postero-lateral or antero-lateral. When one finds such constancy in the situation and nature of the lesion it is not astonishing to find a remarkable degree of similarity in the mode of onset of the clinical manifestations, the differences in each individual case depending upon the level of the lesion.

LOCALITY.

Of the 22 cases in only one was the tumour situated in the lower dorsal and upper lumbar region. In five the tumour was in the lower mid-dorsal region, in 4 in the upper dorsal, in 8 in the cervico-dorsal region and in 4 in the upper cervical region.

ETIOLOGY.

Age. The most common period in which these tumours arise is between the ages of 30 & 50. Of my series of 22 cases, 15 occurred in this period; three

before
~~were under~~ thirty, the youngest being 15, and four ~~were~~
after
~~over~~ 50, the eldest being 65; the average age of the whole series being 40.

Sex. Men are more frequently affected than women in the proportion of 12 to 10.

In none of the cases was there any exciting cause such as injury.

SYMPTOMATOLOGY.

Mode of Onset. The onset is gradual. In the 22 cases of my series 3 cases commenced with pain in the back, 9 with root symptoms and 10 with symptoms of pressure on one aspect of the cord.

Spinal Signs and Symptoms. In the three cases in which pain in the back was the first symptom, the dura was involved, the tumour being anterior in two cases, in one of which it had eroded the vertebræ. In one case only was there tenderness on pressure and in none was there any deformity of the spine.

The early symptoms, whether root or cord, are referred to the side on which the tumour is growing.

Root Symptoms. If the growth implicates the roots the first symptom in pain in the area of the affected posterior root followed by gradual loss of sensation and later by weakness and wasting of the muscles supplied by the corresponding anterior root. The interval which may elapse before the onset of signs of pressure on the cord varies from one or two months to years. On the other hand root symptoms may not show themselves until after the onset of cord symptoms, or may be absent throughout.

Cord Symptoms. If the tumour be situated on a lateral aspect of the cord the earliest symptom is weakness of a spastic type in the limbs of the same side. If the tumour be situated below the cervical enlargement the weakness will be referred to the leg only; the patient complains of weakness, dragging or of a sudden giving way of the limb and sometimes states that the leg feels numb. Whether there is any actual sensory loss or not I have never been able to ascertain, but the cases I have examined have not shown any objective sensory change at this stage. In a certain proportion of cases reflex spasm of the affected limb precedes the onset of weakness and in most cases accompanies it.

Examination at this stage will reveal changes in the reflexes indicating pyramidal affection. The earliest of these changes is the early exhaustion, diminution or loss of the superficial epigastric and abdominal reflexes of the same side below the level of the lesion to be followed by a change in the plantar reflex which becomes indefinite; it may be flexor when the stimulation is applied to the sole of the foot or extensor when the stimulus is applied to the outer aspect of the foot; the deep reflexes on the same side become increased, and with the onset of spasticity clonus may be elicited. All these signs may be present on the side of the tumour before there is any evidence of involvement of the opposite pyramidal tracts.

Sensory Symptoms resulting from Pressure on the Lateral Column. Reference has been made to the feeling of numbness of which a patient sometimes complains in the homo-lateral leg, occasionally pain is also com - plained of, but this, in most cases, is due to flexor spasms in the muscles of the leg and is certainly not associated with any defect of sensibility.

The earliest sensory loss which can be detected is a diminution of sensibility to pain, heat, cold and light touch in the opposite limb below a level situated

two or three segments lower than that of the lesion. This sensory loss usually develops subsequent to the motor weakness on the side of the lesion, but it may occur earlier. I am indebted to Dr Batten for notes of a case (48) which he is going to publish fully later, and which he kindly allowed me to examine, in which a loss to heat and cold on the opposite side preceded the onset of any signs of motor weakness. This is important in view of the differential diagnosis of intra-medullary from extra-medullary tumours.

Another point of interest is the association or dissociation of the loss of these forms of sensibility. I have several cases in which dissociation was present - Cases (50. 51. 55. —) and in other cases where the tumour has been successfully removed the return of sensibility has been dissociated. (47.49.56.61.64 —)

Speaking generally tactile sensibility is more often dissociated from pain, heat and cold than any of the others from each other, but any of them may be dissociated.

The level of the different forms of sensory loss is not coterminous; this is due to the fact that the fibres conveying pain,heat and cold cross more rapidly from their point of entrance to the opposite lateral column than do those conveying tactile sensibility to

the opposite antro-lateral column, thus the level of the loss to pain, heat and cold when present is higher than the level of tactile loss.

The degree of sensory loss may not be universal below the level of the lesion. It is not uncommon to find only a slight degree of sensory loss in the sacral and lower lumbar areas: on the other hand the converse is sometimes noted. This refers only to the remote sensory loss as in cases where there is a local root lesion or in a severe local cord lesion the local sensory loss may be in excess of the remote. See cases

Cerebellar Symptoms due to pressure on the Lateral Column. In the early stages a patient may show a certain amount of ataxia of both lower extremities without any demonstrable loss of sense of position, but as the advent of motor weakness obscures the ataxia and compensation is rapidly established owing to the double cerecellar paths, it is rarely possible to demonstrate this form of ataxia.

The next stage in the development of the symptomatology is arrived at when the tumour exerts pressure on the whole of the cord. At first the tumour only com-

presses the surface of the cord on which it is situated, but as it grows in diameter it displaces the cord and a time arrives when it can no longer be displaced as it comes in contact with the opposite side of the theca, the compression is then exerted on both sides of the cord. When this occurs fresh symptoms arise. Of these the first is reflex spasm and weakness in the previously unaffected limb with changes in the reflexes indicative of pyramidal affection. This onset of bilateral motor weakness is shortly followed by the onset of sphincter trouble. At first there is difficulty in starting micturition which may be followed by retention or incontinence. Constipation also becomes troublesome at this stage, later there is sensory loss below the level of the lesion, at first relative it becomes complete later. Not only is there loss of cutaneous sensibility and deep pain, but also of sense of position. The development of these signs may be gradual or more rapid, but is certainly slower than in the majority of cases of extra thecal pressure.

The final result is first of all complete spastic paralysis with loss of sensation and sphincter control passing rapidly into a stage in which the spasticity becomes replaced by flaccidity with loss of all the deep reflexes and dribbling of urine. The plantar reflexes

may remain for a considerable time after deep reflexes have disappeared, but they too are eventually lost.

Trophic changes become acute in the final stages, the muscles waste, the skin at first pale, atrophied and scaly, may become reddened and the subcutaneous tissues œdematous and bed sores develop at all points of pressure, or even contact, septic absorption, cystitis and pyelitis hastening the end.

Mention must be made of the local cord symptoms. The destruction of the cord at the seat of pressure causes, in many cases, severe local symptoms before the onset of a complete transverse lesion. For example if a tumour be situated involving the roots on the right side of the cord in the cervical region, the symptoms may develop in the following order: -

1. Pain, loss of sensation and wasting in the right arm;
2. Spastic weakness of right leg, sensory loss in left leg;
3. Loss of sensation and wasting in the left arm.
4. Spastic weakness of left leg, sensory loss in right leg;
5. Total paralysis from the level of the lesion downwards.

Stage 3 is due to the local lesion in the cord

~~(William Coster) (Ellen Edwards)~~ Cases 60 64.54.

When the tumour is situated in the anterior aspect of the cord, the early symptoms are bilateral and motor weakness comes on first.

When the tumour is situated in the posterior aspect loss of sense of position is present early and is associated with weakness and spasticity of the legs, the symptoms being bilateral.

DIFFUSE INTRA THECAL TUMOURS.

PATHOLOGY.

The commonest form of diffuse tumour is a sarcoma. It occurs chiefly in children and young adults, and usually starts in the sacral region, involving the roots of the cauda equina and spreading up to surround and compress the cord. These tumours are malignant and tend to spread rapidly. They are primary and secondary deposits are not found elsewhere; they often invade the cord directly passing in along with the peripheral vessels, but not showing any metastatic out-growths, they rapidly cause softening of the cord, not so much from pressure as from interference with the vascular supply and obstruction of the lymph channels.

ETIOLOGY.

Age. 10 to 20 years old.

Sex. Affects boys and girls about equally.

SYMPTOMATOLOGY.

Spine symptoms. There is no bone pain and no evidence of enlargement or deformity of the spine and no tenderness on pressure; these points amongst others distinguishing it from cases of sarcoma of the sacrum.

Root symptoms are early and characteristic, both motor and sensory roots being affected, pain is rapidly followed by loss of sensation and muscular wasting. As the growth is diffuse the root symptoms, if not bilateral from the first, rapidly become so. Commonly they start in the lowest part of the cauda equina and spread up, causing, as early symptoms, pain in the perineum, loss of sensation in the sacral areas, loss of sensation of the passage of urine and fæces, incontinence and later wasting of the legs, paralysis of the lower motor neurone type. All the superficial and deep reflexes of the

lower extremities may become abolished. If the growth starts higher up it may cause root symptoms in the upper lumbar region followed later by compression of the lumbar cord with ultimate softening. In such a case there may be loss of sensation over the 2nd, 3rd and 4th lumbar areas with wasting of the thigh muscle, absence of knee jerks, with increased ankle jerks, extensor plantar responses and sphincter trouble.

Cord Symptoms. These develop rapidly; if at onset unilateral they soon become bilateral; at first the signs are those of simple compression, but soon become those of a total transverse lesion.

CHRONIC PACHYMENINGITIS.

This affection is not nearly so common as chronic leptomeningitis.

CAUSATION.

The causes of this somewhat rare condition are rather uncertain. There is no doubt that the majority of cases are syphilitic in origin, it may however develop as the result of tuberculous inflammation in cases of spinal caries, and it is quite possible that there are other cases in which it is the result of a slow inflammatory process arising from some obscure cause.

Age. The majority of cases occur between the ages of twenty and forty five. The age at which the disease commences depends upon the previous syphilitic infection. Pachymeningitis usually arises within seven years of the primary infection, but may not develop for more than twenty years. Occasionally the development of syphilitic pachymeningitis is associated with formation of gummata in other parts of the body.

MORBID ANATOMY.

Syphilitic pachymeningitis is a comparatively rare manifestation of syphilis. It may result from the direct extension of the disease from the bones of the spine, but more commonly it arises as a localised or multiple gummatous condition. In such cases it most frequently occurs in the cervical or lumbar sacral regions. There is, however, a great tendency for the disease to spread and involve the lepto meninges and later the cord, by spreading along the Septa which pass into it, and obliterating the peripheral vessels.

Tuberculous pachymeningitis. I have never seen this develop except as the result of the direct extension of tuberculous disease from the spine or periosteal structures. I have performed autopsies on two cases in which this form of pachymeningitis was present, and in both there was wide spread caries and the thickening of the theca was most marked on the anterior surface.

Roots. The nerve roots are compressed, and in some cases there is a proliferation of the interstitial tissue and degeneration of the fibres. The roots suffer early before the disease has compressed the cord. In some cases the disease is limited to the cauda equina.

Cord. The cord is compressed only when the thickening of the meninges has extended all round it. This causes first a sclerosis in the peripheral portions and later a transverse lesion. In many cases the disease involves one side of the cord by spreading directly to it, the membranes becoming adherent to one aspect. This is a common occurrence in syphilitic cases. (Cases 77 + 78.)

Cerebro Spinal Fluid. Occasionally it is impossible to obtain any fluid on lumbar puncture although the needle has been correctly inserted, this can only be accounted for by the local condition of the membranes and is rather characteristic of chronic meningeal disease. In syphilitic cases the fluid contains an excess of lymphocytes and the Wasserman reaction is generally positive.

Blood. I have several times obtained a positive reaction in the cerebro spinal fluid, although the blood yielded a negative result. An examination of the cerebro spinal fluid should therefore be made in every case. I do not regard a negative reaction in the blood as of any value unless several dilutions have been tested.

SYMPTOMATOLOGY.

The symptomatology of this condition is characteristic. It is essentially one with root symptoms as the earliest and most prominent feature.

Spine. Local pain is sometimes complained of especially in cervical cases. It is augmented by movement and is often worse at night; there is, however, no deformity although local tenderness is sometimes present.

Roots. The first symptom is usually root pain, but within two or three weeks signs of motor weakness - wasting and paralysis - begin to appear and these are associated with objective sensory loss of the root type. As a rule the condition affects first one nerve, spreading rapidly within two or three weeks to involve the neighbouring roots. Motor and sensory suffer alike. In the majority of cases the roots on both side of the cord are affected, usually at the same level, but during the first two or three months it is astonishing how unilateral the affection may be. I published in the Transactions of the Royal Society of Medicine the Report of such a case. (78.)

Cord Symptoms. Cord symptoms do not as a rule appear for some little time after the onset of root symptoms. It may be a matter of one or two months, or

longer. If the root symptoms are unilateral, it will be found that the cord symptoms indicate an affection on the same side of the cord as the root lesion, spastic weakness on the side of the lesion, with loss of cutaneous sensibility on the opposite side. A good example of this is seen in case (77). In this case there was a history of syphilis six years before the onset of the pachymeningitis. One year before the symptoms commenced, she had been treated for a gumma. The first symptoms were pain, numbness and tingling in the left arm, followed by weakness and wasting. Later she developed slight weakness in the left leg of a spastic type with diminution of sensibility to pain heat & cold on the right side. At the operation a local gummatous meningitis was found affecting the upper dorsal and cervical roots on the left side, and causing some adherence of the membranes to the cord. Operation was followed shortly afterwards by complete recovery from all cord symptoms and a material reduction in the extent of the root lesion. As the disease spreads to surround the cord, the root symptoms become bilateral and paraplegia develops with sphincter trouble and remote loss of sensibility below the level of the lesion. At this stage the signs present will indicate a combination of central & peripheral motor and sensory paralysis.

In cases in which the disease is situated low down, it is not uncommon to find that it involves the roots of the cauda equina, giving rise to root symptoms, and later, as it extends up, it may cause pressure on the cord with evidence of compression. Clinically these cases may simulate either intra-thecal sarcoma, or malignant or tubercular disease of the sacrum. They are distinguished from the latter by the absence of bone symptoms, and by the more rapid involvement of the adjacent roots, as well as by the positive evidence obtained by the examination of the blood and cerebro-spinal fluid. Pachymeningitis is distinguished from the intra-thecal sarcomas by the fact that the latter occur mainly in children and that the development of the symptoms is slower. Again, examination of the blood and cerebro-spinal fluid confirm the diagnosis.

Treatment. The question of the effect of treatment upon this condition will be considered later, but in my experience simple antisyphilitic treatment either with mercury and iodide or with salvarsan does not prove effective. Operative interference is the only way in which to preserve the nerve elements from destruction, owing to the strangulating effect which the meningitis exerts upon them. By operating one can

relieve the roots and cord from this pressure, and it is astonishing how effective antisyphilitic treatment may prove after operative interference.

CHRONIC LEPTO-MENINGITIS.

This condition is by no means uncommon although it may not cause any clinical symptoms. It is frequently found at autopsy in cases which have never presented any spinal symptoms. It is rare to find it before thirty most of the cases occurring after forty. The condition has been described by Schlesinger (18) Krause (17) and Oppenheim (19) but its association with compression paraplegia was recognised many years ago in this country and attention was drawn to it by Sir Victor Horsley in 1909 (20) when he described its symptoms in a review of twenty-six cases upon which he had operated, which I collected for him from the records of the National Hospital.

These cases contained some in which pachymeningitis was also present. In the present instance I have tried as far as possible, to separate the two conditions. An analysis of the cases shews that it is possible to distinguish three forms each of which is more or less distinct in its clinical manifestations - (1) Diffuse lepto-meningitis (2) Circumscribed leptomeningitis with damming up of the cerebro-spinal fluid (3) Localised patchy leptomeningitis with occasionally local collections of cerebrospinal fluid - Arachnoid cysts.

(1) Diffuse lepto-meningitis. The thickening

is most intense along the posterior aspect of the cord and affects chiefly the dorsal, lumbar and sacral regions. It varies in degree but is distributed all round the cord. The roots may be compressed but do not as a rule shew much degeneration. The cord is small and shrunken but pulsation is normal. The degeneration in the cord is most marked at the periphery; ascending and descending degeneration is not well marked, being chronic, it does not shew with the Marchi method and not being intense, the changes seen in Weigert-Sal preparations are very diffuse. Acute lesions are very uncommon and a transverse myelitic condition does not occur. The peripheral changes correspond to the areas when the meningitis is most marked and are due probably to interference with the peripheral blood supply rather than to any actual compression.

(2) Circumscribed Lepto-meningitis. Although the condition may be diffuse yet at one level the lepto-meningitis completely surrounds the cord and is also adherent to the theca with the result that the cerebro-spinal is dammed up at that level. The theca is distended above the constriction with cerebro-spinal fluid. This fluid pressure may cause compression of the cord, which does not pulsate below. That it is the fluid and not the meningitis that causes the compression is

probable because simply incising the theca and letting the fluid escape is often sufficient to restore pulsation and further to eventually allow a complete restoration of function.

(3) Local lepto-meningitis and Arachnoid cysts. It occasionally happens that a lepto-meningitis is confined to one aspect of the cord or to small patches causing no compression of the cord but giving rise to local root symptoms (case 3497). On the other hand such a condition may cause a local locking up of cerebro-spinal fluid either within adhesions or under the arachnoid. This causes local compression of the cord and closely simulates an intra-thecal tumour.

CAUSATION.

The origin of this condition is obscure. Many cases are undoubtedly syphilitic in others the lepto-meningitis is associated with chronic bone disease - caries sicca - and it also occurs in some cases of tuberculous caries and malignant disease. In a large number of cases however it is not associated with any obvious local disease. Some authors consider that it may be a late stage of an acute inflammatory process and in support of this cite cases in which the disease has developed after influenza, but the evidence of the acute stage is not convincing. I think that in a large number of cases it is simply the result of senile change and it is

certainly found in the majority of autopsies performed on old people.

Injury. - A leptomeningitis in the strict sense does not arise from injury though of course a local thickening may occur at the site of the injury.

Alcoholism. - There is no evidence that alcohol has any direct effect except in so far as it may hasten senile degenerative changes.

SYMPTOMATOLOGY.

Chronic leptomeningitis often simulates the clinical features of spinal tumour and indeed the earlier cases which were submitted to operation were all diagnosed as such. Some of these cases were immensely benefited by operation and it has now become the practice to operate on all such cases. From the clinical aspect these cases stand midway between chronic spinal cord lesions and spinal tumours and present many difficulties in diagnosis. In my description, therefore, I shall take typical cases as the standard and will endeavour to show that the three types of chronic leptomeningitis as described in the previous section have each a more or less distinct clinical picture.

Chronic Diffuse Meningitis.

The characteristic clinical feature of this form of lepto meningitis is the very gradual onset of the paraplegia both legs being equally affected. So slow is the progress of the paraplegia that one, two or three years may elapse before the weakness seriously impedes walking. Examination of a patient at this stage reveals a slight weakness of the lower extremities quite general in distribution and with no definite upper level. The deep reflexes are increased and the plantar reflexes may be indefinite extensor in type, but the superficial, epigastric and abdominal reflexes may still be present. The preservation of the abdominal reflexes in the early stages is a sign which is peculiar to this condition. As I have mentioned before, a diminution or loss of these reflexes is one of the earliest signs of pyramidal affection and yet in these cases they are present although the plantar reflexes are extensor and there is definite spastic paralysis of the lower limbs. This could be explained by assuming that the leptomeningitis was situated below the twelth dorsal segment, but I think it is due to the fact that long fibres suffer more than short fibres and that those which pass to the lumbar enlargement are more affected than those which end in the dorsal cord. In the first place, being longer they are exposed throughout a greater extent of their course to the action of the leptomeningitis, and in the second it is well known that the distal end of a fibre, i.e. the

end furthest from the cell of origin which has a trophic influence over the whole fibre, undergoes degeneration sooner than the more proximal parts; this degeneration therefore occurs more readily in the long than in the short fibres.

The next stage is one in which there is an increase in the remote symptoms and a development of local signs. The paralysis becomes more marked and is attended by difficulty in micturition - this taking the form of delay in passing water. Further the patient begins to complain of numbness or pain in the legs often associated with reflex spasms. Examination of the sensory system may still, however, reveal no actual sensory loss. The local signs which develop in this stage are parasthesia or girdle sensation, not of an intense character but spread over a wide area corresponding to five or six segments and bilateral in distribution. There may still be no direct evidehce as to the level of compression but, as a rule, the abdominal reflexes will be diminished although the change in their character as they are tested from above downwards may be so graduated that it is impossible to determine any definite upper level.

The third stage is distinguished by the development of definite localising signs. The motor paralysis may by this time have become so severe that the patient is unable to walk, partly on account of the weakness but also on account of spasticity and spastic contractures. There is now remote sensory loss, as a rule relative

in degree, sometimes bilateral; in other cases more of the Brown Sequard type - the upper limit of this loss can be mapped out. The abdominal reflexes may now be abolished below a certain level which corresponds to that of the remote sensory loss. If the loss is bilateral its upper border will be coterminous with that below which the reflexes are lost, if, on the other hand, the sensory loss is confined to one side its upper border will be situated two to four segments lower than the level at which the reflex is lost on the opposite side. Instead of delay in micturition there will now be incontinence. It sometimes happens that there is a local sensory loss which is more intense than the remote sensory loss, indeed in some cases there is more impairment of sensibility locally than distally ( ). When this exists the corresponding superficial reflexes will be abolished, although they may be present but diminished below this level. Occasionally the corresponding portions of the abdominal muscles are paralysed so that if the lesion be in the upper mid-dorsal region the umbilicus will be seen to descend when the patient attempts to sit up.

To sum up, remote signs appear first and slowly progress, to be followed later by wide spread but relatively slight local signs which eventually become relatively more severe than the remote. Finally a more or less complete lesion of the cord may result.

Chronic Circumscribed Leptomengitis.

In this form of leptomeningitis the onset of the symptoms is gradual but not so slow as in the diffuse type. The lesion is commonly situated in the mid or lower dorsal region. The earliest symptom is progressive spastic weakness, the upper limit of which may become definite within six to eighteen months; it can be ascertained by examination of the abdominal reflexes and observing the action of the abdominal muscles; there is remote sensory loss up to a corresponding level and incontinence of urine is often troublesome. Local signs such as girdle sensation are often present, occasionally associated with pain, but the area over which these signs exist is limited to one or two segments. Occasionally there is numbness in the legs and sometimes pain. In this type of case the first stage may be prolonged from six to eighteen months, but progress is rapid once the definite localising signs have manifested themselves. Thus a patient may have had slight general spastic weakness of the lower limbs for twelve months and then within two to six weeks develop localising signs with evidence of bilateral compression of the cord. The explanation of this is generally found in an obstruction to the cerebro spinal fluid. When the fluid becomes dammed up it at once exerts local pressure on the cord, usually on all its surfaces. Incision of the membranes releases it and removes the pressure; this is followed very rapidly by the disappearance of all the acute symptoms

and signs, provided that operation has not been delayed too long.

Patchy Chronic Leptomeningitis. - Arachnoid Cysts.

(a) In its simplest form there are local patches of meningitis which involve certain roots. The patient complains of pain in a root area, sometimes intense and acute and often made worse on movement, but tending to become less severe within two to three weeks; it ,however does not completely subside and three or four weeks later a loss of sensibility is discovered in the area in which the pain was first felt. Motor root symptoms become obvious about this time, but the patient may have complained of weakness for some little time before he noticed the wasting. The motor and sensory root symptoms correspond. Cord symptoms do not develop until much later, indeed if the primary condition be recognised and adequately treated their onset may be prevented. A good example of this type of case is (97) .

The disease may originate in the cauda equina when the symptoms spread more rapidly owing to the proximity of the roots to each other.

(b) Arachnoid cysts - sub-arachnoid cysts. These terms have been applied to a condition frequently found in association with chronic leptomeningitis in which there are local collections of cerebro spinal fluid, either within the arachnoid or beneath it. It is by no means so rare as one would be led to suppose from a perusal of most text books of neurology or pathology. In my

series of cases I have recorded several such cases, in some of which the symptoms pointed to unilateral compression of the cord and simulated a slow growing intra thecal tumour. There are however several points of distinction In the arachnoid cysts there is often weakness of both limbs before there is preponderating weakness of that on the side of the lesion. Local pain in the back extending round both sides may be an early symptom, but is transient and is often replaced by girdle sensation. Sphincter trouble commences earlier than in spinal tumour cases, and finally the examination of the cerebro spinal fluid may confirm the diagnosis of arachnoid cyst by revealing a lymphocytosis and yielding a positive Wasserman reaction.

SYPHILITIC MENINGO MYELITIS.

I have included in the appendix five cases of syphilitic meningo-myelitis, in all of which operation has been performed. In two of these cases the clinical symptoms point to the meningeal condition having preceeded the myelitic process (101 and 102) as in both, the first symptoms were local pains. In case (101) the pain had lasted for one month before the sudden onset of total paraplegia; for two months he was under treatment with mercury and iodide but shewed no improvement. He was then operated upon and since then has slowly but steadily improved, the paralysis being practically confined to the sacral areas. It is somewhat remarkable that this patient has normal control over his sphincters despite the complete sensory loss over the sacral areas. He did not feel a warmed test tube being inserted into the rectum but was conscious of a catheter at the moment when it entered the bladder. Case (103) illustrates well the greater degree of local sensory loss which may develop in severe cases of leptomeningitis; the loss of sensibility was greatest in the areas of distribution of the fifth to ninth dorsal segments - the portion of the cord where the meningitis was most intense. The remote sensory loss was slight, the fourth and fifth sacral areas escaping, and at the post mortem investigation it was found that there had not been any actual softening of the cord.

STATISTICS

OF DIFFERENT FORMS OF SPINAL TUMOUR.

It is not my intention in this Thesis to enter at all fully into the pathology of Compression Paraplegia, I have confined myself to the description of the different lesions and tumours from the point of view of their physical characters and their effect on the nervous structures. I have done so because on these characters depend largely the mode of onset and the distribution of the symptoms.

I want, in conclusion, to refer to the different forms of spinal tumour which may be met with in regard to their bearing upon the prognosis. I shall consider them in two classes, those situated within the Theca and those in the perithecal space.

I In my series of fourty-nine cases, thirty were intra thecal and twenty-nine were extra thecal.

INTRA THECAL.

The majority of Intra Thecal tumours are slow growing and localised. They arise from the membranes or the sheaths of the spinal roots - in this class fibro sarcoma, endothelioma and psammoma are included.

In a smaller proportion of cases the tumours are not localised and are of a malignant character. The commonest of these is Sarcoma - usually round-celled. They may originate in the endothecal space or may involve

it from without, either by direct invasion or by metastasis. Direct invasion takes place either along the roots or by way of the cerebral membranes. A beautiful example of the former was shewn by Dr. Farquhar Buzzard at the Neurological Section of the Royal Society of Medicine, three years ago. I have never seen any examples of direct extension from the cerebral membranes, although several cases of this nature have been described. In one of mine the tumour, a myxosarcoma, spread up to involve the meninges over the medulla ( ).

Metastatic growths are sometimes met with; the infection is occasionally carried by the cerebro spinal fluid. Barnes in 1902 (12) published a case of sarcoma of the cerebellum which had involved the cord by extension down the central camal and underneath the pia arachnoid. In I published reports of several cases of choroidal tumour situated in the fourth ventricle; in one of these I found secondary growths around the central canal upon the roots and around the cord. They were almost microscopic and it was only on microscopical examination that I was able to verify their nature. Since then I have found another example of this condition and I append two photographs to illustrate it. In neither of these two cases was there any clinical evidence of involvement of the cord or spinal roots. Metastatic growths from visceral tumours

are sometimes met with, such as Carcinoma, Sarcoma but of these I have no examples.

INTRA THECAL TUMOURS.

Nature.	Fibro Sarcoma.	Sarcoma.	Endothelioma.	Psammoma.	Angioma.	Intra & Extra Medullary Double Lesion.
Male	9	2	2	0	0	2
Female	5	5	1	2	1	1
Total	14	7	3	2	1	3
Average Age.						
Male.	43	34	33	-	-	35
Female.	44	32	42	38	30	9

EXTRA THECAL TUMOURS.

Of these a considerable number grow from the theca and are of a similar nature to those found growing within the theca - Fibro Sarcoma and Endothelioma. Intra sarcoma and endothelioma may, however, also arise from the structures lining the boney walls of the vertebral canal. These tumours are not highly malignant but are certainly not so benign as those arising from the

theca itself. The other perithecal tumours are mostly secondary and the result either of extension from the spine itself or from tumours situated elsewhere in the body and may be purely metastatic. Direct extension from visceral growths takes place along the roots through the intervertebral foramina, or between the laminae. Metastatic growths are usually multiple and their occurrence in the spinal cord is only part of a general metastasis.

EXTRA THECAL TUMOURS.

Nature;	Fibro Sarcoma:	Sarcoma:	Endothelioma:	Carcinoma.	Gumma:	Total.
Male	4	4	4	0	0	12
Female:	2	3	0	1	1	7
Total	6	7	4	1	1	19

DIFFERENTIAL DIAGNOSIS OF INTRA- AND EXTRA- THECAL TUMOURS.

Intra-thecal. The symptomatology of intra-thecal tumours differs according to the nature of the tumour. The slow growing non-malignant tumours are very similar in their clinical picture to the corresponding type of extra-thecal tumour. The malignant differ, and more closely resemble the malignant type of extra-thecal tumour. I shall therefore contrast the slow growing intra-thecal and the slow growing extra-thecal, and later the rapidly growing intra-thecal with the rapidly growing extra-thecal.

In Slow growing Intra-thecal Tumours - the onset is gradual, the symptoms commencing usually between the ages of thirty and fifty. Symptoms referred to the spine are uncommon; in some cases there is local pain but deformity is quite exceptional and tenderness on pressure very uncommon. The mode of onset of the symptoms is first unilateral cord or root symptoms. Of twenty-two cases ten began with cord symptoms, nine with root symptoms and only three with pain in the back. These root and cord symptoms are referable to a lesion compressing one side of the cord.

In cases where the roots are affected there is first

local root symptoms on one side, pain and motor and sensory loss, followed by a gradual onset of paralysis of the lower limb of the same side and by loss to pain, heat and cold on the opposite side some segments below the level of the root lesion. This is followed still later by a gradual onset of paralysis of the opposite leg, the onset of sphincter trouble, and the development of sensory loss on both sides up to the level of the local lesion. Still later there may be a complete transverse lesion with local signs on both sides at the level of the compression and total paralysis below.

In slow growing Extra-thecal Growths the age of onset is similar but symptoms referred to the spine are more common; these are local pain and occasionally tenderness on pressure, deformity, however, is rare. The onset of the cord and root symptoms is similar to that of slow intra-thecal growths, and may also be of the Brown Séquard type, but this is not so constant a feature. The final development of complete paraplegia is more sudden and there is little interval between the onset of the bilateral compression and the development of a complete transverse lesion.

RAPIDLY GROWING INTRA-THECAL AND EXTRA-THECAL TUMOURS.

Intra thecal. This type of tumour occurs chiefly in the early years of life from ten to twenty and is more often situated in the sacral region than elsewhere. There is no local pain in the spine and there is no spinal deformity or tenderness on pressure. There is an early onset of root symptoms and they rapidly become bilateral, are soon followed by cord symptoms except in the sacral cases. There is rarely any unilaterality in the cord symptoms and the lesion very rapidly progresses to become total.

Extra thecal. These often arise in late childhood or early adult life, and chiefly affect the dorsal region. Local pain and tenderness of the spine are very common but deformity is rare. The course of the disease is rapid at first, root pains followed by rapid onset of bilateral cord symptoms which soon become those of a total transverse lesion.

Pachymeningitis. This is distinguished from spinal tumours by the rapid onset of the root symptoms which are severe and spread and extend so as to involve several roots within six to eight weeks. The cord symptoms do not, as a rule, develop until the roots on both sides

are affected, but this is not invariably so. Once cord symptoms develop the progress towards a complete transverse lesion is rapid. The diagnosis is confirmed by lumbar puncture and cytological and serum examination.

Leptomeningitis. The local symptoms are diffuse and widespread but are not intense in degree. The earliest symptom is diffuse spastic paralysis of very gradual onset, usually bilateral, with retention of the abdominal and epigastric reflexes, these disappearing later when local signs indicating the level of the lesion appear; the progress of the case is slow throughout; the diagnosis is confirmed by lumbar puncture and cytological and serum examination.

Local cystic formations may simulate spinal tumour, but again examination of this cerebro spinal fluid may help in the diagnosis.

SARCOMA OF THE SPINE.

Sarcoma of the spine may simulate spinal caries or spine tumour.

It simulates spinal caries in cases where it gives rise to obvious signs of vertebral disease and as it may occur in young people the diagnosis is often difficult.

The signs are swelling, sometimes soft and boggy, sometimes nodular, which may involve the surrounding muscles and tissues. The swelling, however, is limited to the affected area, and does not like a burrowing abscess appear at some distance from the vertebral lesion. There is local tenderness on pressure which, however, does not often cause root pain, and pain on movement is less common than in caries. The local pain is more constant and gnawing in character. In young people sacral caries is rare while sacral sarcoma is relatively common. In sarcoma one root is involved after another, an appreciable interval intervening, and symptoms are late in appearing, several roots being affected before there are signs of compression of the cord. Radiography may be helpful, caries being more easily recognised than sarcoma.

In cases of secondary sarcoma, especially cases of lympho-sarcoma - the differential diagnosis is still harder. The presence of enlarged glands and the mode

of onset of the symptoms - root pain followed rapidly by bilateral compression of the cord - are common to both, but in caries there is a more acute local deformity.

Examination of a gland may solve the question. Tuberculin tests are of doubtful value; Von Pirquet's reaction may also prove misleading especially in adult cases. Lumbar puncture is often negative in both caries and sarcoma, but as it is sometimes positive it may help in clearing up the diagnosis.

The cases of sarcoma of the spine which simulate spinal tumour are those in which the sarcoma is primary and slow-growing; it may then pass into the vertebral canal without causing any local deformity. Tenderness on pressure may be present in both conditions and in both there may be long standing root symptoms. A case of this type resembles slow growing meningeal tumour in its clinical features. Radiography may be of great value in distinguishing the two conditions provided the situation of the tumour permits of photographs being taken in several positions. Both types of tumour will give a shadow. The patient should first be photographed lying flat on his back with the spine next the plate, and later two oblique photographs should be taken, the spine being rotated so as to give a lateral view

In meningeal or intrathecal tumours the shadow of the tumour is not in constant relation or connection with that of the vertebral bodies whereas vertebral tumours will be seen to be in direct connection with the vertebræ. Further meningeal tumours tend to extend parallel to the cord on one side, while vertebral tumours tend to extend across the vertebral canal.

CARCINOMA OF THE SPINE.

The diagnosis of this condition is not as a rule difficult, the advanced age of the patient, the history of previous operations for tumour or the presence of malignant disease elsewhere all point to carcinoma. In addition there may be a severe degree of cachexia as in most cases the disease is well advanced before it affects the spine. The local spine symptoms are pain - often very intense and always aggravated by pressure - to this may be added a slight or severe degree of local deformity which is never, however, so acute as the angular curvature seen in caries.

Radiography may be helpful, but as the diseased bone may show either as a shadow or as a light patch the most careful interpretation of the photograph is necessary.

The onset of root and cord symptoms is rapid and the lesions soon become complete.

THE DIAGNOSIS OF EXTRA FROM INTRA MEDULLARY TUMOURS.

The differential diagnosis of extra-medullary spinal tumour from intra medullary must be based upon the incidental symptoms and the grouping of the spinal symptoms.

Deformity of the spine may occur in syringomyelia but not until the disease is well advanced, whereas in caries, the deformity often precedes the spinal symptoms. In syringomyelia the symptoms are generally referred to the lumbar or cervical region, or even to the bulb. The local symptoms in syringomyelia precede the onset of the cord symptoms, but the character of the sensory loss is different from that due to posterior root lesions and is not accompanied by root pain, although burning pain may be complained of in similar, but not identical areas. Trophic disturbances are severe and may appear in the early stages. In spinal tumour cases root symptoms are followed by signs of involvement of the homolateral side of the cord, and later of the other side. In syringomyelia both pyramidal tracts may be affected at the same time. The Brown Sequard type of paralysis is rare in syringomyelia, but common in spinal tumours. A definite segmental loss is rare in syringomyelia but typical in extra-medullary spinal tumours. In syringomyelia there may be an upward extension of the symptoms but in extra-medullary tumours this is almost unknown.

The symptoms in syringomyelia are often remittent, those of spinal tumour progressive. Dissociated sensory loss may occur in both cases, but the remote loss is more segmental in distribution in cases of tumour than in the central cord lesions.

CONCLUSION.

I have endeavoured in this Thesis to make a systematic exposition of the fundamental principles - anatomical, physiological and pathological underlying the production of the signs and symptoms of Compression Paraplegia in general.

What I have, however, especially endeavoured to elucidate is the manner in which these fundamental signs and symptoms vary in the different groups of cases and the reasons for such variations. In this manner it appears to me possible to establish criteria of differential diagnosis which do not appear to me to have been hitherto sufficiently emphasised.

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