Lesions of the Spinal Cord occurring in cases of Visceral Cancer

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My attention was directed towards the investigation of spinal cord lesions in cases of visceral cancer by observing certain clinical symptoms which occurred in the later stages of cancer of the head of the pancreas. The symptoms pointed to inflammatory mischief of a myelitic nature, involving the cervical enlargement, and in one case in this series this diagnosis was verified on post-mortem examination of the cord. But with further investigation of a series of cases, lesions of a different nature were found, and it is a record of my findings in this series which forms the subject of my thesis.

The result of my observations on the spinal cord up to the present time will be classified under three headings:

1. Diffuse myelin atrophy: this constantly occurs in visceral cancer.

2. Disseminated myelitic foci: these are less common than the atrophic changes.

3. Isolated posterior root lesions which apparently are least common and, as I hope to show below, have a special significance with regard to one of the principles governing the pathology of the spinal cord.
I propose to describe these three varieties of lesion in detail, and will attempt to discuss their etiology in the light of what is known of neurology at present. I have encountered many points in my work on which opinions must necessarily differ, and these I leave open for the present, but there are certain definite facts which it seems to me are worthy of record, and capable of explanation.

The cases from which my material was obtained were as follows:—

1. Cancer of the prostate with secondary deposits in the liver, some undergoing degeneration.

2. Cancer of greater curvature of stomach near the pylorus with secondary nodules in the liver.

3. Cancer of omentum with secondary deposits over the small intestine.

4. Cancer of the pancreas with secondary nodules in the liver; the pancreatic tumour had at one spot broken down into greenish pus.

5. Cancer of pylorus with secondary deposits in the liver some of which were degenerated.

6. Cancer of head of pancreas with secondary deposits in the liver, pleura, and kidneys: some of those in the liver were degenerated.

7. Cancer of Pylorus with direct invasion of the liver.

The cords of four of these cases were cut in
every segment; in the other three, sections were taken from the various regions.

The technique in every case was the following:--

The tissue was hardened and fixed in Potassium bichromate (2%), embedded in celloidin, and the methods employed to demonstrate the morbid changes were Walter's modification of Weigert's method, Van Gieson's and Marchi's methods, Haematoxylin and Eosin staining, and also the Safranin method as detailed in Cornil and Rangier's Text book.  

As indicated above, my description of the lesions found in the spinal cord of cases of visceral cancer is divided into three headings, the first of which deals with the diffuse atrophic changes in the myelin. These, as above mentioned, are constant features, and any differences met with in my series of cases are only those of degree: the situation of the lesion never varies.

My description of these may be prefaced by saying that the areas principally involved are the posterior columns, the lateral columns and the grey matter.

**CHANGES IN THE COLUMNS OF THE CORD.**

In recording the changes seen in the series of cases examined, I propose to take as a typical example that from a case of adeno-carcinoma of the stomach with secondary nodules in the liver. The others conformed closely to this, and the differences noted
Cervical Segment II.

1. Posterior horn.
2. Atrophy in Burdach's column.
3. Atrophy in Goll's column.
were rather in degree than in situation. This was one of the cases examined in every segment, so that the description will be facilitated by frequent references to the Chart No. I.

In the posterior columns of the cervical region the myelin atrophy was very profound posteriorly, comprising the inner part of Goll's tract in its two posterior thirds: narrow in front, it broadened out to the posterior periphery, appearing triangular in shape with base posteriorly. In this area very many of the myelin sheaths had disappeared entirely. To a less extent the atrophy spread outwards on either hand from the posterior half of this area along the periphery. The myelin throughout the rest of the posterior columns was little affected, and, even in the situations where the myelin rings had disappeared altogether, it was noticed by Van Gieson's method that the axis cylinder processes were still quite intact. (See photo). In segment No. 3 the triangular area of profound degeneration became narrowed posteriorly, and that part stretching out along the periphery was less in degree.

There was some atrophy scattered throughout Burdach's columns, but not to the same extent as that in the central part on either side of the posterior median septum.

In the remaining segments of the cervical region
Cervical Segment VII.

Considerable degree of atrophy round the anterior third of posterior septum.

Dorsal Segment V.

1. Diffuse atrophy of the posterior columns.
2. Obverse loss of fine fibres in the grey matter.
the atrophy with loss of myelin was situated further forward; so that in the 4th and 5th Segments there was an area of comparatively healthy fibres at the posterior periphery, while the atrophy in Burdach's column became more marked. In the 6th, 7th and 8th segments, however, atrophy was seen nearer again to the posterior periphery although not reaching it in any great degree, and the atrophy, described above as being central along the median septum, reached the grey commissure, extending at the same time more widely outwards. (See photo). In the lower segments, around many of the arterioles, one noticed that the myelin was preserved in a much better state, and these lines of darkly staining myelin stood out in strong contrast to the paler areas between the vessels.

POSTERIOR COLUMNS OF DORSAL CORD.

The area of greatest atrophy and absolute loss of myelin was again on either side of the posterior median septum, extending from the grey commissure backwards for two thirds of the distance between it and the posterior periphery. The shape was triangular or swallow-tailed, the base or forks being posteriorly, and the apex narrow in front in most of the upper segments; lower down one could hardly map off a triangle, the whole of the columns being diffusely atrophied, one part almost as much as another and all to a less extent than higher up. The parts least af-
Sacral Segment I.

The root-entry zones (1) stain better than the remainder of the posterior columns (2).
fected being a narrow zone round the periphery and
the root entry zones. (See Photo).

**POSTERIOR COLUMNS OF LUMBAR CORD.**

These columns showed a diffuse atrophy, but the
posterior periphery and the root entry zones were
affected least. There was a diffuse absolute loss of
myelin in individual fibres, those remaining showing
little change from the normal. Here too there was
not much advanced atrophy about the posterior median
septum as higher up in the cord: many of the apparent
spaces being due to thickened vessels not, of course,
stained by this method.

**POSTERIOR COLUMNS OF SACRAL CORD.**

These showed a diffuse disappearance of myelin in
isolated fibres. (See photo).

**GREY MATTER.**

The fibres of the grey matter showed myelin
atrophy throughout all the cord. (See photos).

The above description is a general one, but in
some cases the appearances showed some slight differ-
ences: for example, in the cervical region the myelin
might be preserved in the immediate vicinity of the
postero-lateral septa with atrophic changes on either
side, most marked however, as in the above described
case, in Goll's tracts. Sometimes, too, the triangular
area of atrophy found in the two first cervical
segments was not so well marked. All these differences seem to me to be only those of degree and have been noted in cases from pernicious anaemia, Addison's disease, and in experimental poisonings.\(^2\)

**LATERAL COLUMNS OF CERVICAL REGION.**

In the 1st, 2nd and 3rd segments there was noticed much atrophy in both anterior and posterior spino-cerebellar tracts (Gowers & Flechsig). Inwards from these areas there was some much slighter atrophy encroaching on the pyramidal tracts and basis bundles. In the 4th cervical segment, the opposite condition held: the great bulk of the atrophied fibres being situated in the basis bundles and pyramidal tracts, while myelin was well preserved in Gower's and Flechsig's areas. In the remaining segments all the tracts were more or less atrophied but the basis bundles and pyramidal tracts more so than the periphery.

**LATERAL COLUMNS OF DORSAL REGION.**

In these columns the basis bundles and pyramidal tracts were diffusely atrophied throughout, and the atrophic change did not extend to the periphery of the cord except from the 9th to the 12th segments, at which level, however, we must remember the spino-cerebellar tracts in the lateral regions of the cord are as yet ill-developed.
LUMBAR AND SACRAL LATERAL COLUMNS.

In the upper thoracic segments there was still considerable atrophy of myelin, and in the first two it reached out to the periphery as in the lower dorsal segments; thereafter it progressively diminished down to the last sacral segment where there were only a few atrophied fibres on the right side.

MYELIN CHANGES IN DETAIL.

The myelin, as viewed in transverse section of the fibres, showed all degrees of atrophy; from a slight thinning to almost colourless refractile rings or parts of a ring. Many had lost their round contour, becoming irregular in shape, and taking up the stain unequally so that only parts of the ring were stained, or one part might be stained darkly and another of a much lighter shade. On inspection with a low power, or even with the naked eye, the areas of atrophy could be easily mapped off from the more darkly staining healthy fibres.

Another change, which I am inclined to call oedema was noticed. It usually affected the outer parts of the cord and was characterised by great swelling of the myelin with expansion of the lumen of the tube, which became often oval in shape or quite irregular. This oedematous change must be clearly separated from the myelin atrophy usually met with in cases of cancer,
as it differs very markedly from atrophy both in situation and in its morphological characters; another difference may be noted, viz:—that in the oedematous areas there was no neuroglia hypertrophy or proliferation.

In the centre of the myelin ring there was a substance of a myelogenous nature which stained faintly by Walter's Method; this substance may be possibly altered myelin or on the other hand, it may be only one of the components of myelin, but as the composition of myelin is still decidedly subjudice, this point may be left open, for the present. In contrast to this when one examined an atrophic area, the myelin rings showed all the stages of atrophy detailed above, were never swollen and their lumen was invariably clear, further, as we shall see below, in all the atrophic areas there is neuroglia hypertrophy and proliferation.

The situations in which this oedematous change was found were, in most cases, chiefly in the lateral columns at the periphery, involving the two spino-cerebellar tracts on both sides, but not limited to these, extending more anteriorely and also inwards towards the grey matter, but those fibres nearest to the grey matter were least affected.

In one case this oedema was especially marked, not only in the lateral columns but also in the anterior and posterior, in the latter of which it
extended, in the upper segments of the cord, from the posterior periphery almost to the commissure, while lower down it was chiefly at the periphery as in the lateral and anterior columns.

This case differed from the others, in that the appearances were very much more pronounced, involved more of the fibres, and were very noticeable in the posterior columns, which were not involved to any extent in any of the other cases.

This curious swelling of the myelin sheath has been observed in a variety of diseases and has received special attention from Minnich who described it in the cords of cases of pernicious anaemia and carcinoma. He found that the spinal cords of such cases, after hardening in Potassium Bicromate showed lighter staining in the posterior columns as contrasted with the usual yellow staining seen in nerve tissues which have been in bicromate for some time. This is a condition frequently found in primary degeneration and was pointed out many years ago by Vassale. On treating with the Carmine method the myelin was found to be swollen, some of the axis cylinders ruptured, the vessels not altered, and no morbid change of the neuroglia in the affected area.

Petren has found similar changes in the cord from a case of liver abscess, in which there was thrombosis of the pial veins.
Mayer has seen similar appearances in cases of brain tumours, as has Lubarsch, in the cords of cases of carcinoma. This oedematous change is common, too, in Diabetes. (Williamson, Kalmus, Songues and Marinesco).

The pathology of the oedematous change is still very obscure and a perusal of the literature affords us little help. The change is certainly an ante-mortem one, and not in any way dependent on post-mortem changes as, although one delays the post-mortem examination for 48 hours, oedema of the cord remains as rare a condition as ever. On the other hand I have examined cords from cases of cancer six hours after death in cold weather and in two cases the degree of oedema was so great as to render the tissue a pulpy mass, extremely difficult of manipulation even with the utmost care. These facts support the view that the condition is an ante-mortem one, and one of rapid development occurring shortly before death, but as to the mechanism underlying the condition I have at present no theory to advance.

I do not consider that this oedematous change has the same importance as the other changes mentioned in this thesis, for as it occurs presumably shortly before death, it is in all probability caused by some factor incidental to the terminal phases of life.

It is just probable that shortly before death some very acute general intoxication occurs, which causes
rapid swelling and oedema of the myelin.

I had the opportunity of comparing my sections with those prepared by Doctors Orr and Rows, who have found a similar condition in the cord of rabbits into whose abdominal cavity a celloidin capsule, containing a broth culture of a virulent strain of the Bacillus Coli, had been introduced. The appearances which I have described under acute oedema are strikingly similar with the results obtained in the above experiments. These authors find the same oedematous condition of the cord and the same peculiar swelling of the myelin sheath, and regard the change as the result of an acute toxaemia.

NEUROGLIA CHANGES.

These were both proliferative and hypertrophic, and occurred chiefly in the posterior columns on either side of the posterior median septum in the area of greatest myelin atrophy. The change was not confined to this part, however, but spread out, in most of the segments, as far as Burdach’s Column, the root entry zones escaping. In the first cervical segment of this case in which the posterior part of Goll’s column showed so much atrophy there was practically no neuroglia change, in the second cervical segment proliferation and hypertrophy appeared along the posterior median septum and from this point
Observe gliosis proliferation especially in the vicinity of the postero-median septum.

Dorsal Segment

Thickened vessel in postero-median septum.

Cervical Segment
downwards the change became diffuse except in the root entry zones and at the posterior periphery. In the lateral columns there was some hypertrophy, not nearly so marked as in the posterior.

Round the vessels the change was especially marked, the cells and thickened processes forming in some areas a sort of extra casing, many of the processes being attached to the adventitial coat. The neuroglia cells round the central canal were also much proliferated.

The change consisted in a proliferation of the cells, which were swollen and contained an enlarged nucleus; the processes were very much thickened. (See Photo)

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**VESSEL CHANGES.**

The vessels were morbidly thickened throughout and showed hyaline degeneration chiefly in the middle and adventitial coats; the nuclei of the intima were apparently healthy; some of the smaller vessels were almost impervious, especially in the posterior columns. The pia and its vessels also showed hyaline degeneration. (See photo).

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**CENTRAL CANAL.**

The lining cells were very much proliferated, usually filling up the entire lumen, and around it there was considerable proliferation of the neuroglia.
CONCLUSION.

To sum up, it may be said in the first place that the above described lesions in the spinal cord show characters that are altogether different from those found in systematic diseases such as tabes dorsalis. In system lesions, such as the above, the sclerosis follows the anatomical pathways of the nervous fibres, and shows little tendency to spread beyond this until late in the disease. In cancer on the contrary the lesions are characterised by their diffuseness, and, especially in the posterior columns, by an utter absence of anatomical continuity. For example, (see chart) Goll’s column may show a marked Sclerosis high up in the cervical cord which at first sight might lead one to presuppose the existence of changes in the root entry zones at a lower level, but systematic examination invariably demonstrates that the root entry zones are free from degeneration all the way down the cord. It is noteworthy too, that in some cases the pyramidal degeneration is not seen at a higher level than the third cervical segment.

When we consider that the crossed pyramidal tracts, basis bundles, and the fibres in the grey matter are involved, as well as the posterior columns, it is obvious that whatever morbid action underlies these degenerations, it is not one showing a special predilection for any one particular order of neurons,
Dorsal Segment I

1. Atrophy of fibres in grey matter.
2. Atrophy of basis bundles.
3. Diffuse atrophy of posterior columns.
but rather for several simultaneously. Where exactly the process first begins is a difficult matter to decide. Its effects are certainly greatest in the cervical and upper half — roughly speaking — of the dorsal cord, and it would seem as if the lesion gradually extended downwards to the lumbar extremity. Why the upper regions of the cord should be attacked first is difficult to explain, but that such is highly probable one may gather from a study of acute processes affecting the same areas.

For example, lesions remarkably similar in situation and extension are found in chemical poisoning, after extirpation of the thyroid and para-thyroid glands (Jacobsohn, Minor, Flatau), in poisoning from bad maize (Sereni), and after picratotoxin (Riva) and mercurial poisoning (personal observation) — (See Photo); somewhat similar lesions are found in pellagra, uraemia, leucaemia and Addison's disease.

In the acute and subacute forms of poisoning, the changes invariably affect the cervical and upper one third of the dorsal cord and the lumbar region may be perfectly normal.

We may therefore assume by analogy that in the much more chronic disease of cancer it is the above regions which suffer first, and extension has taken place to the lumbar region by the time one obtains the material for examination. Such a view is supported by finding the more chronic lesions in the
1. Bernad's Tract - showing much less atrophy.

2. Atrophy of Golgi's tract.
upper levels of the cord and from an examination of
the cord from a case of carcinoma of the pylorus in
which the cord affection was of recent date, and of
a more acute nature than usual. In this cord there
was well marked atrophy in the upper cervical seg-
ments; in the lower segments it was much less, and
disappeared altogether at the 3rd dorsal. (See
photos).

In comparing the lesions in these cords from
cases of cancer with those found in toxic conditions,
the question may be asked are the lesions under dis-
cussion caused by a cancer toxin or by certain toxins
derived from infection of the primary or secondary
growths. The hypothesis that a toxin of some kind is
the cause of the degenerative changes will be amply
supported in section III; but as to whether the toxin
is derived solely from the cancer cells or from some
other super-added condition, such as infection of the
primary or secondary growths must be left an open
question for the present.

On looking at the distribution of the myelin-de-
generation one is at a loss to find any adequate
explanation for it in the light of present day know-
ledge. As indicated above, the lesions are in every
respect unlike a systemic lesion, and any attempt to
explain the localisation must necessarily be of a
very hypothetical nature until the pathology of toxic
lesions in the cord has been further investigated.
There is always one possible explanation which arises in one's mind, that whatever strands of fibres are affected they are those whose resistive power has been weakened by some inherited or acquired defect, but on this point we have no data on which to build a legitimate hypothesis.

It might be advanced that the localisation of the degenerations might be connected in some way with the time at which the tracts in the cord receive their myelin sheaths during ontogenetic development. As we know that the tracts of the cord are not all medullated at the same time, some much earlier than others. Further, Flechsig, and later Trepinski, showed that even in the posterior columns the fibres composing them may be divided into definite groups according to the period of myelinization; it might be suggested, therefore, that the toxins selected certain groups of fibres in preference to others, i.e. that certain systems were more vulnerable to toxic action. But a comparison of the lesions under discussion with the areas figures by Trepinski demonstrates that in this direction one cannot look for an explanation of the distribution of the cord lesion in the posterior columns, nor is one in a better position with regard to the lesions in the lateral tracts and grey matter.

All that one may say at present is that these areas of myelin atrophy are identical in situation
with those seen in many varieties of general intoxication, and not only are they identical in this respect, but also in that they are characterised by the same type of degeneration, viz - a slow progressive primary degeneration of the myelin, without any Wallerian change.

This primary degeneration of the myelin sheath is always associated with intoxications of haematogenous origin, and is to be clearly separated from those of lymphogenous origin if we accept the opinion of Orr and Rows. These authors point out that haematogenous lesions of the cord - the result of a general intoxication - are always of a diffuse nature and involve the areas which I have described in detail, and the morbid change is a slow atrophy of myelin: this as I have shown is always accompanied by neuroglia proliferation and hypertrophy, with thickening of the walls of the vessels. Marchi's method gives negative results. When the infection of the cord, however, is lymphogenous such as occurs along the spinal nerves (Orr and Rows), the lesion is a systemic one affecting the root entry zones of the posterior columns, and the Marchi Method in most cases gives a positive reaction. From my work it is evident that the cord in cases of cancer may be infected as the result of a general intoxication (haematogenous), or from toxins ascending in the lymph stream of the spinal nerves (lymphogenous).
The haematogenous lesion is by far the most common and forms this, the first section of my thesis. The lymphogenous lesion is never so constant and will be dealt with in section III.

With regard to the neuroglia proliferation and hypertrophy, it has been mentioned that this was seen to affect the areas in the cord which showed myelin atrophy, but is most marked in the vicinity of the posterior septum and around the vessels near it. As to whether the neuroglia reaction is primary or secondary to alterations in the higher elements is a difficult point to decide from my series of cases alone, but on extending my observations to acuter conditions such as a case of mercurial poisoning, I am inclined to this view that the neuroglia reacts to the effects of the toxin which causes the myelin changes, as well as to the irritating effects induced by the products of degeneration. The manner in which the neuroglia is found showing reactive changes around the vessels especially, not only in chronic but in acute intoxications inclines one to seriously entertain the view expressed by Lugaro that the neuroglia exercises some special protective function in the central nervous system, acts perhaps as a filter and neutralises the action of certain
substances passing from the vessels to the higher elements, substances which would exercise a deleterious action. This view is still a pure hypothesis, but receives some support from both the physiological and pathological side. It is well known that neuroglia cells are found in close contact with nerve cells, lying in the recesses between the protoplasmic processes and the cell body, in which position they are advantageously placed to counteract the effect of substances circulating in the blood, either the result of ordinary metabolic processes, or those which are the result of morbidity. The manner in which neuroglia hypertrophy takes place so markedly around the vessels seems to suggest that these cells form a physiological barrier against noxious products proceeding from the vessels into the nervous tissues.
In this section I propose to deal with certain myelitic lesions which occurred in the cord of one of the cases associated with definite symptoms during life.

These myelitic lesions may occur along with the atrophic lesions detailed in section 1. of this thesis, and, although apparently a rare occurrence, I am inclined to think that if cords from cases of cancer were systematically examined, the condition would be found to occur more frequently than is at present imagined.

I was recently told the history of a case in which the symptoms consisted in a rapidly developing weakness of the muscles of the shoulder girdle associated with a considerable degree of pain. No definite diagnosis was made but everything seemed to point to some inflammatory mischief in the cord itself or in the meninges, and the patient died rapidly of exhaustion without any amelioration of the nervous symptoms. This case was of interest to me as it was brought to my notice shortly after commencing my observations on the spinal cord lesion in visceral cancer. On the patient dying, permission was given to open only the thorax and abdomen, when a cancer of the head of the pancreas was found with many secondary nodules in the liver.
The case whose cord I examined had unfortunately been in the asylum for many years: he was very demented and the examination of his sensory disturbances was extremely difficult, so that a minute clinical examination of the condition under consideration was quite impossible. There was herpes affecting the dorsal region at the level of the fifth rib on the right side, extending forwards almost as far as the sternum. There was a slight degree of herpes in the distribution of the first and second divisions of the fifth cranial nerve; this nerve was found to be very gelatinous-looking and soft at postmortem examination. In the case-book it was noted that there were choreiform movements affecting chiefly the jaws and arms, which lasted for three weeks previous to death.

As I anticipated finding some unusual lesion in this cord I arranged to examine every segment by all the methods available for the demonstration of atrophic, degenerative and inflammatory lesions. In this case I do not propose to give a description of the atrophic lesions, as these were the same as given in section 1, but will confine myself to a description of the myelitic foci. These were demonstrated by the Marchi method, the haematoxylin and eosin method, by Van Gifson's method and by the safranin method.

In reading the description of these myelitic
Two areas of softening.

Lumbar Segment V.
foi and the ascending degenerations to which some of them - those in the posterior columns - gave rise, it will be found useful to refer at this point to the accompanying chart. The myelitic foci only are marked in red.

The majority of these discrete foci occurred in the cervical region, so I will dispose of those lower down first.

In the fifth lumbar segment there were two small foci, one at the posterior margin of the cord in the immediate vicinity of the posterior median septum, and another of equal size in the left root entry zone close to the posterior nova and midway between the commissure and the margin of the cord. (see photo)

I met with no more of these foci until reaching the sixth dorsal segment where again there were two, but in a different situation: one was situated in the right lateral basis bundle, the other in the left lateral basis bundle but somewhat anterior to the first one.

In the first dorsal segment there was a very small focus in the anterior basis bundle on the right side, just anterior to the lateral extension of the anterior grey horn; as the diagram shows, this was a very small focus indeed.

On looking at the chart, an area of degeneration
obviously a root lesion — is seen to occupy the left root entry zone of the sixth cervical segment. These peculiar root lesions occurring in the course of visceral cancer will be dealt with in the third section of my thesis, and all I should like to say on this subject at present is, that the degeneration of a root so affected can be traced upwards in the posterior columns and is seen in the accompanying chart (see C.V, IV & III) to follow the anatomical pathway, i.e., recedes inwards, as it ascends, towards the median septum.

Before proceeding to a description of the myelitic foci in the higher cervical segments and the ascending degenerations resulting therefrom, I should like to mention with regard to the foci in the fifth lumbar segment that these were not followed by any secondary degeneration; it is obvious therefore they occurred very shortly before death.

On passing from the sixth cervical segment to the fifth, two definite foci were seen; one comparatively large situated on both sides of the middle third of the postero-median septum, another very small situated slightly to the left hand side of the above mentioned septum. Both gave rise to ascending degenerations therefrom, the larger one being recognisable as two sides of a triangle on either side of the posterior septum and ultimately terminating in the
Cervical Segment I

Degeneration from root lesion in C. VI.

Small area of softening.

Cervical Segment II

Degeneration from root lesion in C. VI.
Passing upwards and backwards.

Degeneration from area of softening around foramen in C. VII.
The degeneration resulting from small vessel in C. VII.

Cervical Segment III

Ascending degeneration from softening in C. III.

Ascending degeneration from softening in C. VII.

Note. These plates are taken from sections of tissue prepared by Marchi's bainic acid method.
nucleus gracilis of the medulla; the smaller one showed as a small oblique band which passed backwards towards the postero-internal part of Goll's column on the left side, and was only traced as high as the second cervical segment. (see photos)

In the third cervical segment there were two moderately large myelitic foci: one in the anterior part of each cuneate fasciculus; both gave rise to well marked ascending secondary degenerations, which were traced into the cuneate nucleus of the medulla on both sides. (see photos)

In addition to these foci in the posterior columns, there were two in the lateral columns, one small one in the second cervical segment just about the junction of the two right spino-cerebellar tracts, and in the first cervical segment, another, a little smaller, situated about the middle of the right posterior spino-cerebellar tract of Flechsig.

The only other focus encountered was situated in the medulla, at the lateral margin of the left anterior pyramid, at the level of the inferior extremity of the lower olive.

The above description of those discrete myelitic foci applies only to my findings with the Marchi method; all, however, were examined by methods suitable for demonstrating the changes in the axis-cylinder vessels and connective tissues.
1. Swollen axis of bundle.
2. Loss of tissue around a vessel; here the degenerated axis of bundles stained very faintly or not at all.

Note the absence of inflammatory cellular reaction in Photo XVII. KIXVII
THE MORPHOLOGICAL CHANGES.

In heading this chapter "myelitic foci" it is more than probable that the correct term to be employed should be "softenings", as the appearances in the areas involved differ very considerably from what is called acute Myelitises.

The foci in question were compared with sections taken from a case of acute transverse myelitis which lived for six weeks after the onset of the attack; it will be advisable however, to give in detail the changes which I found in my series of cancer cases before entering into a comparison with those usually met with in a true myelitis.

In all the foci the marked feature was the swelling of the axis-cylinders. This swelling varied in degree, some fibres being only slightly enlarged, while others were of enormous size as may be seen in the accompanying photograph - (see photo). The less swollen axis-cylinders kept their shape fairly well, but the more swollen ones showed considerable variation in contour: some were oval, others pyriform and others quite irregular. With safranin they stained a cherry red colour.

The majority of axis cylinders were preserved, and as above mentioned stained more deeply than usual: they were surrounded by a clear space, due, in some instances, to expansion, in others to a loss
of the connective tissues. Some axis-cylinders, however, had undergone degeneration and were represented only by a faintly staining amorphous mass of indistinct outline. One naturally expected to find degenerated axis-cylinders in the cervical region seeing that there was ascending degeneration from each of the foci in the posterior columns there.

There was little evidence of neuroglial proliferation, but here and there some thickening of the processes and enlargement of the cells was noted.

The vessels showed a marked degree of hyaline thickening in the neighbourhood of the softened areas and elsewhere, and two of these were cut in serial section to demonstrate if possible the exciting cause of the softening process, but without success; probably whatever vascular change there was, whether the result of hyaline thickening, thrombosis or embolus, was obliterated in the general tissue destruction.

On comparing these foci with sections from a case of acute myelitis, one found in the former a marked absence of cellular reaction, both haematogenous and histogenous. There were a few lymphocytes in the adventitial sheath of the vessels and only a very few compound granular corpuscles; as above mentioned there was a slight degree of neuroglial reaction. The appearances suggested a tissue destruction or necrosis more than an inflammation.

On the other hand acute infective myelitis is
characterised by a well-marked inflammatory reaction. The vessels are engorged, sometimes thrombosed, and their wall filled with migratory cells. The whole cord is infiltrated with leucocytes, the nerve fibres are necroosed, and the neuroglia cells are swollen and proliferated. A variable degree of meningitis is always present.

The picture in a case of true myelitis therefore is so different from what is found in the foci under discussion, as to strongly suggest that they are not inflammatory in nature, so that we have to seek for some other explanation.

Disseminated foci of softening or myelitis, as some call them, are found in the cords taken from cases of pernicious anaemia, and I have seen them also in a case of Addison’s Disease. Nóline has observed these foci in leukaemia and septicaemia and considers they may be caused by myelitis or multiple haemorrhages, but these myelitic foci and haemorrhages although coexisting are met with independently from each other; they occur in all regions of the white and grey matter of the cord and even in the medulla. The myelitic foci described by Nóline are characterised by swelling of the axis cylinders, and even of destruction of them, unaccompanied by any neuroglia reaction or the presence of compound granular corpuscles. The foci are intimately con-
nected with the vessels which are often thickened and hyaline, or may, even be obliterated (Le Noble).

The Haemorrhagic foci contain many compound granular corpuscles, and blood in all stages of re-absorption. The myelin in the affected area is fragmented and reabsorbed, the axis-cylinders are swollen at first, then become atrophied or destroyed and the neuroglia proliferated. It is quite common to find softenings in the cord in Caisson Disease which are apparently due to gas emboli in the vessels inducing an ischaemia. Nikiforoff found, 24 hours after the commencement of the disease, small foci in the white matter; the glial mesh-work was sometimes empty, sometimes filled with more or less swollen axis cylinders round which was a myelin sheath greatly reduced in size. The vessels were congested, the perivascular lymph sheaths dilated, with here and there small isolated haemorrhages; at a somewhat later stage (15 days) Leyden found similar changes, and in addition compound granular corpuscles lying in the tissue spaces. According to the above authors the foci seemed to correspond with the distribution of the vessels in the cord.

Recently Boycott and Damant have induced Caisson disease experimentally in animals, and the part of their paper which deals with the occurrence of necrosis in the cord is extremely interesting. This necrosis is confined to the central portions of the
white matter; the periphery of it and the grey matter were unaltered. Without going into the incidence of these softenings with regard to the special region of the cord affected, it is interesting to know that the lesions can be correlated with the "thrombotic lesions - so-called myelitis - in man".

All the evidence, therefore, goes to show that the foci in cancer cases are not truly myelitic, but are better described under the term "softenings".

They must be the result of interference with the blood supply, due either to thrombi, emboli, or anaemia the result of hyaline thickening of the vessel wall. In the case under discussion the latter hypothesis is the most unlikely, for there was evidence of a general blood infection, shown by the presence of recent endocarditis, affecting the aortic valve. This may have been the result of bacterial infection of the degenerating cancer nodules. It is just possible that some minute vegetations were carried in the blood stream up the vertebral arteries and thence into the spinal arteries. In confirmation of such a hypothesis we have the fact that the cervical region was affected far more profoundly than any other; on this point, however, one wishes to avoid dogmatism, and would refrain from giving any definite opinion until more cases of a similar nature are met with and examined.
This the last section of my thesis, which deals with the intramedullary posterior root lesions occurring in the cord of cases of cancer, forms one of the most interesting and difficult problems from an etiological point of view.

These isolated root lesions, so far as my experience goes, appear to be of rare occurrence, and, in the series of cases on which my research is founded, only three examples were met with. In one cord - the cord in which there were multiple softenings and recorded under section II - the left sixth posterior cervical root was found degenerated in its intramedullary portion. The degeneration commenced at the point where the posterior root fibres lose the neurolemma sheath, and filled the root entry zone, (see photo and chart). In only one other case did I find isolated posterior root lesions, and here two roots were affected in the dorsal region, viz, the sixth left posterior and the second right posterior roots; in the latter, however, the degree of degeneration was much less than in the other two instances.

On discovering those lesions and noting their systemic character, one naturally thought of some morbid action in connection with the extramedullary portion of the nerve as the causative agent, such as pressure from a cancerous growth affecting the intra-
or extradural portions of the nerve. The result of examination, however, showed clearly that pressure on the sensory nerve could be entirely excluded.

The methods employed were, as before, Marchi, Walter, Van Gieson, Safranin, and Haemotoxylin and Eosin. Transverse sections were taken of the posterior nerves between the dura and the cord. The nerve as it passed through the dura mater was cut serially in longitudinal section along with the anterior nerve which is here closely applied to it, in order to study certain special changes which have attracted a considerable degree of attention during the last few years. I refer to the work of Nageotte, to be considered later.

One of the nerves - the sixth left dorsal - was also studied between the dura and the posterior root ganglion: of this portion serial sections were again stained by all the above named methods, and the examination was controlled by sections taken of a root in whose corresponding intramedullary portion there was no degeneration.

Let us commence with a description of the pathological changes found in the above mentioned sixth left dorsal root, beginning at the posterior root ganglion and passing upwards through the dura mater to the cord margin. Both motor and sensory nerves were included in the section.

In the extradural portion of this nerve the most
1. A fociculus of the posterior root.
2. Cell clusters in the lymph spaces of the periadenium.
striking feature was the infiltration of the lymph spaces of the perineurium with collections of cells: the nuclei of these were round or slightly oval in shape, the majority stained deeply, but some were rather pale and irregular in outline as if undergoing degeneration. (See photo) The cell body was difficult to demonstrate but one could see that the cell was of the epithelial type.

In the perineurium these cells were packed tightly together, and had caused considerable widening of the lymph spaces; (See photo) here and there were collections in the epineurium between the fasciculi. Only at one spot were these cells observed to invade the nerve tissue; this was near the ganglion and only in a few consecutive sections; they were few in number forming a very small cluster. The most noteworthy feature of this cell formation in the whole length of the extradural portion of the nerve was its tendency to keep strictly to the lymph spaces of the nerve sheath.

The nerve sheath was not infiltrated by these cells in its entire circumference, the collections lying in the vicinity of some fasciculi more than others, and, although the perineurium seemed to form a barrier against the invasion of the nerve fibres, yet here and there in the inner parts of the perineural sheath extremely little tissue separated the clusters of
1. Atrophy of one fasciculus of the posterior root.
2. Slight atrophy of anterior root.
proliferating cells from the nervous structures.

It is a matter of great difficulty to come to a definite conclusion as to the nature of these cellular proliferations. It was obvious that they were either of an endothelial nature or of a cancerous nature, a secondary deposit of the original cancerous growth situated in the greater curvature of the stomach; but perhaps the point is better left over for the present until we have described the cellular changes in connection with the sixth left cervical root of another case.

Especially interesting are the changes in the medullary sheaths of the nerve accompanying the above cellular changes. The myelin was atrophied, but in a manner so peculiar as to exclude the secondary degeneration which accompanies destruction of, or pressure upon a nerve. Two fasciculi in particular were affected, viz:—the anterior root and the largest fasciculus of the posterior root, (See photo), and just external to the dura there was a higher degree of myelin atrophy than in any other part of the extradural portion of the nerve. Another striking peculiarity of this atrophic change was its patchy distribution, a point well brought out by the serial method of examination, which showed how in any one fasciculus, a portion of healthy nerve intervened between an atrophic portion above and below it.
On examining the myelin sheaths with a high power in sections stained by the Waller and Safranin methods the abnormal myelin rings showed a variety of appearances. Some were very thin in their whole circumference, in others again only a segment of the circumference stained and sometimes very faintly; in other fibres the myelin was swollen and stained more deeply than usual, while the contour of the sheath was irregular in shape; here and there along the nerve many fibres had lost their myelin altogether. (See Photo)

As indicated above such appearances are characteristic of primary atrophy of the myelin, such as is found in toxic conditions.

No constant relationship could be made out between the presence of the proliferated cells in the peri- and epineurium and the atrophy of the nerve fasciculi. Often where the cellular proliferation was most marked the myelin sheaths were healthy, and in segments where the myelin atrophy attained a considerable degree the cellular proliferation was slight.

Another important point noted in this connection was that the perineurium of the anterior nerve showed very little thickening and no cellular infiltration. There was proliferation of the cells of the endoneurium, but as we have seen above there was a considerable degree of myelin atrophy.

The perineurium of the sensory nerve was thickened.
Diagrammatic Scheme to show how Nageotte differentiates the various portions of the spinal roots.
as were the trabeculae between the fasciculi, but to a less extent; and in the anterior root and in the large fasciculus of the posterior root the nuclei of the endoneurium and the neurolemma cells were increased in number.

The two nerves, anterior and posterior, as they pass through the dura mater were cut serially in longitudinal section; these sections included a considerable portion of the nerve traversing the subdural space in order to ensure a comparison between the changes affecting what Nageotte calls the radicular portion and the subarachnoid portion of the spinal nerves, (See diagram).

The two nerves where they pierced the dura mater were surrounded by large numbers of cells of exactly the same appearance as those in the perineurium of the extradural portion, (see photo). In number these cells, in this situation, were greatly in excess of those found in the extradural portion; they did not invade the nervous structures at any point and showed a distinct tendency to leave the vicinity of the nerve and pass into the layers of the dura. Here they formed clusters as before.
This cellular proliferation was strictly limited to the region of the nerve enclosed in the small pouch of dura mater which surrounds it just before the nerve becomes extradural, and on examining the roots between this point and the cord no cells of the type under discussion were found.

The changes in the myelin sheaths of both anterior and posterior nerves were most interesting in view of the work done in the last few years by Nageotte, on the pathological changes found at this point in incipient tabes and in cases of cerebral tumour, it would be as well at this point to give Nageotte's views and theories, and a synopsis of his description, as his work must be criticised in this part of my thesis.

Nageotte has observed, in conjunction with many other writers, lesions of the intramedullary posterior root system. He has demonstrated these by the Marchi and other methods, and found certain particular changes in the extramedullary portion of the posterior roots on which he has built a theory to account for the intramedullary lesion in the posterior columns.

Nageotte on purely pathological grounds, and not on any anatomical foundation, divides a spinal nerve into two portions; the lower portion is bounded below by the junction of the sensory nerve with the posterior root ganglion, while its upper limit is a variable point slightly internal to the portion of the nerve where
it pierces the dura. This segment he terms the "nerf radiculaire." The portion of the two roots situated between the upper limit of the "nerf radiculaire" and the cord margin is termed by Nageotte the sub-arachnoid portion. (See diagram p. 37.)

Now Nageotte has found in cases of cerebral tumour and tabes dorsalis a meningitis and transverse neuritis which commences near the point where the superior third of the "nerf radiculaire" joins the lower two thirds, and he assumes that this transverse neuritis induces a dystrophy of the posterior root fibres which commences at their terminals within the cord, and spreads backwards through the root entry zone to the cord margin.

It will be seen at this point that Nageotte has to account for the relative and in many cases absolute integrity of the posterior root fibres between the cord margin and the focus of transverse neuritis situated in the "nerf radiculaire;" and it is just here that he becomes involved in a maze of theory, which, though ingenious, cannot be accepted until many facts connected with the normal anatomy of the posterior root ganglion cells receive further attention, and the manner in which their processes react to toxic stimuli is worked out. To this point we will refer later, and think it advisable at the present stage to give a short synopsis of the changes found by Nageotte in the "nerf radiculaire." These changes in the nerves are both degenerative and regenerative,
and it is to the presence of regenerative changes that Nageotte ascribes so much importance.

At the above mentioned focus of transverse neuritis Nageotte finds a peri-and endoneuritis accompanied by destruction of the myelin sheath, while the axis-cylinders are preserved; the preservation of the axis-cylinders is an important point. Very frequently there are slight changes in the meninges without any definite changes in the nerves. Below and above the neuritic focus the nerve tubes may be practically normal. Along with this degenerative change there are regenerative phenomena shown by the presence of bundles of fine fibres which occupy the old sheath of Schwann.

In a paper of more recent date Nageotte has demonstrated, in tabes, by Cajal's new silver-reduction method that the cells of the spinal ganglia and their axones can give rise to fine fibres: these are apparently compensatory to the destruction of the original root fibres and tend to pass from the ganglion toward the cord. Some gain access to the posterior root, but none succeed in pushing their way through the neuritic focus. I have not examined this special point with Cajal's new methods as this would be a research in itself, but will show later by other methods that there is an enormous number of fine regenerating fibres to be found in both posterior and anterior roots between the neuritic focus and the cord.
Nageotte's observations are no doubt perfectly correct and I have found almost precisely similar changes in the posterior and anterior roots, where they pierce the dura, in the cords of cases of cancer when the corresponding cord segment showed a root lesion in the root entry zones. It will be better, however, to give in detail the changes I have found in the "nerf radiculaire" in my series of cases before criticising Nageotte's deductions regarding their connection with the lesion found in the root entry zone of the corresponding spinal segment.

At the point where the nerves passed through the dura mater there was great loss of myelin in both the anterior and posterior roots, but more marked in the anterior root; by Walter's method it was seen that the large majority of fibres had lost their myelin sheath entirely, in others the sheath was exceedingly thin and stained faintly, the axis cylinders were swollen but not markedly so. As the sections through this portion of the spinal nerve were longitudinal and cut in serial section, transitional stages were easily followed inwards along the nerve towards the cord, and the following appearances were noted. Just internal to the point above described the myelin degeneration was not so extreme; the myelin sheath was fragmented into pieces of varying shape, some were ovoid or spherical, isolated or joined together by a narrow
Atrophied portion of nerve passing through muscle.

Nerves remaining in muscle sheath as it approaches the cord.

Degenerating fibres showing necrosis.
1. Atrophied myelin sheaths.
2. Fine sinusoidal regenerating fibres.
1. Degenerated myelin
2. Fine regenerating fibres

3. Degenerating fibres mixed with regenerating ones.
thread. The fragmentation assumed many forms as will be seen in the accompanying photograph. It was interesting to note that, as one passed along the nerve towards the cord margin, the change in the myelin sheath became less marked until the large majority of fibres were quite normal in appearance.

In the part of the nerve internal to the most degenerated part (passing through the dura) one first encountered the fine fasciculi characteristic of nerve regeneration. These regenerating fibres could be best observed in the partially degenerated segment between the normal internal portion and the markedly degenerated portion passing through the dura. There were great numbers of these regenerating fibres, and they were fairly closely packed together; each was thin, sinuous in form and myelinated at irregular intervals (see photo); the myelin stained well both by Walter's and the safranin method, and the latter stain demonstrated a very fine axis-cylinder. Very often one could note how the myelin was arranged in the form of a small segment to one or other side of the axis-cylinder, or surrounded it in the form of a small head or globule. In this nerve regenerating fibres were found both in the anterior and posterior roots.

In the situations where degeneration and regeneration were present there was a very marked proliferation of the cells of the endoneurium and of the neurolemma,
Observe the Marchi reaction of degeneration in the left root entry zone of the sixth dorsal segment.
1. Left root entry zone filled with degenerated fibres.
2. The point where the sensory fibres lose their neurolemmal sheath; it is here degeneration begins.
3. Extramedullary portion of nerve clothed with neurolemma and showing no degeneration.
4. Some scattered degeneration in the crossed pyramidal tract.
The portion of the posterior root in the immediate proximity of the cord margin was examined in transverse section by Walter's, Van Gieson's and Marchi's methods. It was found that the nerves were practically healthy, a few in two fasciculi showing a slight degree of degeneration by Walter's method, (See photo). Marchi's method gave an almost negative result in strong contrast to the positive reaction shown in the intramedullary part of the root; by Van Gieson's method one found thickening of the fibrous trabeculae and a moderate degree of nuclear proliferation.

As mentioned above there was degeneration of the sixth left sensor\(\texttt{a}\) cervical nerve in the case in which there were multiple softenings. The degeneration in the posterior root entry zone by Marchi's method was considerable and the extramedullary part of the nerve, including Nageotte's 'nerf radiculaire', was examined by the same methods as used in the nerve we have just described. It is unnecessary to detail the degenerative, regenerative, and inflammatory changes found in this case as they were practically the same in nature as those found in the other.

There were certain differences, however; there were fewer proliferated cells around the nerve, and they differed somewhat in appearance from the cells found in the perineurium of the nerve in the other case: the nucleci did not stain so deeply and appeared more of the endothelial type. Both anterior and posterior
roots, just internal to the dura mater, showed marked atrophy, but fine regenerating fibres were seen only in the posterior root. There was a transverse neuritis, and a few lymphocytes were seen in the vicinity of the vessels, which were dilated and congested. Between the neuritic focus and the cord margin the nerve was healthy.

For purposes of comparison the fifth left cervical nerve from the same case was examined in its extramedullary course, as in the corresponding segment there was no intramedullary lesion. The only pathological changes found were a proliferation of endothelial cells between the perineurium and the dura mater, where this is pierced by the spinal nerve, a very slight degree of atrophy of myelin at the same level, and a slight degree of transverse neuritis. This nerve was also cut in serial section and stained by the methods already mentioned.

If we summarise the above details, we find we have to deal with four main facts, viz: - a degeneration in the posterior root entry zone of the cord which is demonstrable by the Marchi method, an almost healthy posterior root until a point close to the dura is reached, a transverse neuritis where the spinal mixed nerve pierces the dura mater and a well marked cellular proliferation around the nerve at this point, and, so far as my observations extend at present, in the perineurium
and epineurium as far down as the posterior root ganglion.

It is obvious that in my thesis I must leave many problems connected with the pathology of the posterior roots untouched, especially those which have reference to the regenerative phenomena described by Nageotte in his work. When one considers that the morphology of the posterior root ganglion cells and their connections, and the way in which they react to pathological processes will undergo revision in the light of the recent work of Cajal, Dogiel, Marinesco and Nageotte, it must be obvious that one is face to face with a special research in pathology which I must leave untouched.

For example Dogiel in his work on the morphology of the posterior ganglion cells mentions a multipolar type which possesses dendrite-like structures: these are partly medullated and partly non-medullated and pass into the posterior roots to terminate in sensory organs. Until we know how these behave under abnormal stimuli the question of the genesis of the regenerating fibres in the posterior roots cannot be adequately discussed.

The point at issue it seems to me, so far as it applies to my thesis, is whether the lesion in Nageotte's "Nerf radiculaire" is the cause of the intramedullary lesion, or merely a concomitant of a toxic condition of the cerebro-spinal lymph. That a lesion of the "nerf
radiculaire can induce a dystrophy of the intramedullary portion of the nerve backwards as far as the cord margin still requires more proof than Nageotte advances at present. Although he attempts to account for the integrity of the posterior root between the cord margin and the transverse neuritic focus on the ground of regenerative phenomena, such an explanation is still extremely hypothetical and begs the question that this part of the nerve at one time has been degenerated. Nor is it always the case that the lesion in the spinal cord is in direct proportion to the degree of transverse neuritis in the "nerf radiculaire" as shown by the fact that in the sixth cervical root entry zone, there was more degeneration than in the sixth dorsal root entry zone, while the degenerative change at the "nerf radiculaire" was greater in the latter. Further there was a slight degree of transverse neuritis in the fifth left cervical nerve and the intramedullary part of the root showed no degeneration.

It is now known that toxins can pass up in the lymph stream of the spinal roots and cause degeneration of the intramedullary part of the fibres without any participation in the process of a neuritis at Nageotte's point. Orr has recorded a case of suppuration around the nerves of the left brachial plexus, in which the disease lasted only 10 days, and the toxins passing along the nerves induced degeneration of both anterior and posterior roots within the cord. It is
apparent that in this case there could not have been
time for the development of the phenomena to which
Nageotte draws attention. Since then Orr and Rowe
have confirmed and extended these observations by
experiments on animals, and have observed lesions in
the posterior columns without any transverse neuritis
in any part of the spinal nerve.

The involvement of the intramedullary portion of
the motor nerve is a strong argument against Nageotte's
view, and his statement that the new formed fibres
coming from the posterior root ganglion cells or their
axones do not succeed in crossing any focus of inter-
stitial neuritis does not help his theory that regenera-
tion takes place in the subarachnoid portion of the
nerve. It seems to me that here we would require to
fall back upon the theory of auto-regeneration from the
neurolemma cells, a theory of regeneration which has few
supporters, or, that the new formed fibres grow out
from the old axis cylinders. This might hold for the
subarachnoid portion of the anterior nerve which is still
in communication with the trophic centres in the ante-
rior cornua but it does not obtain for the subarachnoid
portion of the posterior nerve in which the neuritic
focus intervenes and separates it from the trophic
centres in the spinal ganglia.

The more obvious conclusion, therefore, is that
the intramedullary portion of spinal nerves tends to
degenerate under the influence of toxic action, when
they lose the protection of the neurolemma sheath whose function, from what we know from nerve regeneration, is of the highest importance.

It is quite obvious that this transverse neuritis, described by Nageotte, can no longer be restricted to tabes dorsalis or to tabetiform lesions, for we find it here in cases of visceral cancer and occurring in an isolated fashion, not generalised as in a tabetic cord amongst the lumbo-sacral nerve roots.

As we now possess sufficient evidence to show that toxins can pass up the spinal nerves from definite septic foci (Orr & Rows) and affect the part of the cord which gives origin to these nerves, I am inclined to take the view that the inflammatory lesions in the spinal nerves and the intramedullary lesions found in my cases and in other conditions are the result of one and the same process. One can easily understand how toxins ascending in the lymph spaces of the perineural sheath will give rise to irritative phenomena with a certain amount of patchy degeneration of the myelin sheath. So long as the nerve is protected by the neurolemma it is still capable of reaction and regeneration, but in the cord where the neurolemma is lost the myelin must inevitably show a more acute degenerative change and repair is impossible.

To glance for a moment at the extra-dural portion
of the sixth dorsal root it will be remembered that the perineurium showed a marked degree of proliferation of cells. I have submitted these cells to several authorities as there has been considerable controversy as to whether some of or all of them are cancerous or epithelial. The opinions obtained have been contradictory, and as I am continuing my researches on this point I leave the question open. If the cells are of a cancerous nature then the isolated intramedullary lesions in the cords taken from cases of visceral cancer are in all probability the result of cancer toxin passing upwards to the cord, but, if the cells are epithelial their proliferation is probably the result of toxic stimulation from some secondary cancer focus lower down in the course of the nerve. It is accepted that cancer spreads along nerves by direct continuity, so that one has to consider the possibility of cancer affecting the sympathetic system and toxins thus gaining access to the lymph stream of the spinal roots. The whole question, however, will require the investigation of a larger series of cases than I have been able to obtain, and so my object in this thesis has been merely to point out the three types of lesion in the spinal cord which I have found in cases of visceral cancer and advance the most probable explanation of their genesis.
Chart I (from Alexander's Amines Atlas of the Spinal Cord)

The atrophic areas are shaded in pencil.
Chart II (from Alexander's Brain, atlas of the Spinal Cord)

This chart shows the myelitic focæ in red, and the recent superficial degenerations in black.
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