Experiments employing variations in blood pressure as a guide to sensory conduction have as yet proved less definite, but point to the same conclusion.

Anatomical Changes in the Cord produced by Concussion and Compression.

After concussion by 50 grams falling 1 and 2 cm. the changes in the cord at the point struck were trivial. They consisted of small haemorrhages in the grey matter, usually in the basal region of the posterior cornua or in the posterior grey commissure, scattered swellings of axis cylinders and disintegration of myelin sheaths. Compression for short periods produced similar changes. After more severe injuries there were more marked anatomical changes, particularly in the grey matter. These consisted, as before, in haemorrhages, with swelling of axis cylinders and disintegration of fibre sheaths.

The vessels of the cord were not occluded by thrombosis, therefore the disturbance in structure could not be attributed to thrombotic softening by secondary degeneration. Sections stained by Marchi's method displayed both ascending and descending degeneration. The number of degenerated fibres varied with the severity of concussion, but even where this had been inflicted from a height of 10 cm., the resulting degeneration was less pronounced than might have been expected from the disturbance in conduction. After concussion from 30 and 40 cm., however, the degeneration was very extensive.

Ascending degeneration particularly affected Goll's column and the direct cerebellar tracts, but after the more severe injuries the area showing degeneration extended round the margin of the cord as far as the anterior fissure. Below the lesion degeneration was seen in the pyramidal and anterior tecto-spinal tracts.

The Part played by Interference with the Circulation.

1. *State of Circulation at the Site of Injury.*—Though haemorrhages of varying extent were caused by concussion and compression, these were due to rupture of small vessels, for no thrombotic processes could be detected in the larger vessels. Apparently, therefore, there was no gross circulatory obstruction at the site of injury.

2. *The Effect of Obstruction of the Aorta upon the Conductivity of the Cord.*—The conductivity of the spinal cord rendered anaemic by aortic compression has been studied by Loewenthal,⁷ in whose paper a bibliography of this subject will be found. His experiments were performed upon cats, the aorta being digitally compressed in the thorax after resection of the sixth or seventh rib on the left side. To counteract the possible effect of deficient aëration artificial respiration was maintained. He found, in the first place, that after one or two minutes stimuli reaching the anterior cornual cells produced no motor response, but that the first effect of arrest of circulation upon the functions of the spinal cord was an increase in the readiness and strength of intraneural transmission of nerve energy lasting for thirty seconds.

In certain of the animals he observed convulsive phenomena in the posterior half of the body at the commencement of ischaemic paralysis, which, in his opinion, deserved the name of "spinal fits." Also, he considered that probably every single neuron as a functional unit retains its vitality for a period exceeding fifteen minutes, but that the mechanism linking them is rapidly destroyed.

In the present experiments motor conduction in the cord could not be demonstrated by cortical excitation fifteen to thirty seconds after the arrest of circulation, which is a much shorter interval than that described by Loewenthal.

No conclusions have as yet been arrived at regarding the initial increased response to excitation, nor did any of the animals exhibit convulsive phenomena. It must, however, be remembered that in the present research a smaller portion of the cord was rendered anaemic than in Loewenthal's experiments.

The arrest of circulation for fifteen minutes at the level of the twelfth dorsal vertebra was followed in the dog by considerable paraparesis, which was obvious after twelve days had elapsed, and was most noticeable in the anterior tibial muscles. Unfortunately no dogs survived arrest of

circulation for thirty minutes at this level. On the other hand, little paresis was produced by obstruction half an inch distal to the renal vessels.

It may also be mentioned that ligation of the aorta in the cat just distal to the inferior mesenteric artery produced no degeneration in the spinal cord.

It follows, therefore, that arrest of its blood supply rapidly causes a loss of conduction in the spinal cord, a result which may be reasonably ascribed to its action upon the interneuronic mechanism.

CONCLUSIONS.

The provisional conclusions to be drawn from these experiments are as follows:

1. The spinal cord is extremely sensitive to slight degrees of concussion and compression.
2. Despite the slight anatomical changes demonstrable after lesser degrees of injury, the resulting disturbance of function is considerable.
3. After concussion which has quite abolished motor efferent conduction, sensory conduction can still be demonstrated.
4. Arrest of the spinal cord circulation by aortic compression abolishes spinal cord function in from fifteen to thirty seconds.
5. These experiments support the view that there is an organic basis for the signs and symptoms of "railway spine" and allied conditions of traumatic neurasthenia.

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PSEUDO-FRACTURES OF TRANSVERSE PROCESSES.

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ABOUT three years ago I published in the BRITISH MEDICAL JOURNAL the radiograph of a man whose lumbar spine showed an apparent separation of the left transverse process of the first vertebra. In that case there was no history of injury. Since that time I have met with five other cases of a similar kind showing the same abnormality of one or more processes.

The condition seen in most of the spines referred to was a distinct gap between the outer end of the process and the base. In three of them there was also displacement of the outer end upwards or downwards, so that it was not difficult to imagine that muscular strain had fractured the process and torn away the tip. In two of the cases the bony edges of the gap were thickened and curled as though callus had been formed.

In one man the tips of the third and fourth left transverse processes were displaced downwards for quite half an inch, and in a radiograph which I published in the JOURNAL in October, 1910, the second, third, fourth, and fifth left processes were much displaced. In this last case there was a definite history of muscular strain, the man being a collier. He complained of pain on the opposite side of the spine, but, finding the condition described, he was assumed to have fractured the processes.

In the light of subsequent cases I very much doubt if this was a case of muscular strain causing fracture. In only one of the other cases I have mentioned was there any history of injury, and that was a fall on the buttocks, which could not, I think, in any way have accounted for the abnormality seen, namely, an apparent separation of the first left transverse process. In this case also the pain was referred to the opposite side.

The psoas magnus, quadratus lumborum, and erector spinae are all attached to the transverse processes, and any violent lifting strain might, of course, snap the processes at their weakest point; but one would expect, first, displacement in each case, and secondly, union of the fractured bone where there was no great displacement, and not a permanent gap.

I think that the cause of these conditions is developmental, and in support of this view there is, first of all,

the absence of any injury in almost all the cases, and secondly, the fact that the first lumbar is the most frequently affected vertebra. In one case both transverse processes of this vertebra showed a distinct gap. The

Fig. 1.—Showing a typical pseudo-fracture of the first lumbar transverse process.

epiphyses of the transverse processes are not united until the twenty-fifth year, and in the embryo there is a costal element in connexion with the transverse process of the first lumbar. Occasionally this develops into a rudimentary

Fig. 2.—First lumbar, showing gaps in both transverse processes.

supernumerary rib, in fact the transverse processes are homologous with the first part of the ribs, and the appearance of such rudimentary ribs would correspond with the condition seen in some of these cases. Incomplete ossifica-

Fig. 3.—Rudimentary ribs attached to first lumbar vertebra. (After Allen Thomson.)

tion of the processes would also, of course, account for the transparent gap seen in some of the processes. All the six cases I have mentioned were those of adults, the youngest being about 20, the oldest nearly 60 years old.

The importance of such abnormalities in claims under the Workmen's Compensation Act was, of course, obvious from the first, but another aspect lately came to my notice in a case where a surgeon proposed to cut down upon and remove what had been diagnosed as an ununited fracture of a transverse process.

The accompanying diagrams show the appearance seen in most of the cases referred to.

A CASE OF TETANUS TREATED WITH INTRASPINAL INJECTIONS OF MAGNESIUM SULPHATE.

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THE following is the record of a case of tetanus treated with intraspinal injections of magnesium sulphate:

A boy, aged 8 years, was admitted into the Great Northern Hospital on the morning of September 3rd, 1912.

History of Illness.

Quite well previous to August 30th. On that day did not seem well, and noticed some difficulty in opening the mouth.

On August 31st had "some kind of fit" and fell down.

On September 1st and 2nd had attacks of pain, becoming rigid, but with no loss of consciousness. The jaw remained stiff after the attacks.

Previous History.

No fits previously and no illnesses. One month ago fell and cut right side of head, and three weeks ago fell and cut chin. Both cuts slight.

Condition on Admission.

Well developed boy. Conscious and understands perfectly. Mouth tightly shut. Slight "risus sardonicus." Neck rigid. No squint. Ocular movements perfect. Pupils equal and react to light and accommodation. No head retraction. Body rigid. Arms and legs stiff but easily moved and flexed. Knee-jerks present on both sides. No cuts or septic foci. The temperature was 98° F. and the pulse 112 and regular.

During the afternoon of September 3rd he had several slight spasms, during which he cried out, and became rigid, with slight opisthotonos. In the early part of the night the spasms became very frequent. In these the mouth was tightly shut, there was marked risus sardonicus and opisthotonos, and apparently great pain.

Treatment.

Lumbar puncture was then performed, and 10 c.cm. of cerebro-spinal fluid, which was under considerable pressure, were withdrawn. Without removing the needle there was then injected into the subdural space 3 c.cm. of a sterilized 25 per cent. solution of magnesium sulphate. Following this the spasms ceased, and the patient had a quiet night.

On September 4th the temperature rose to 101.4°. The pulse remained between 100 and 120. There were no spasms during the day, and the mouth could be slightly opened. There was still general rigidity. On the 5th the temperature fell from 101° to 99°. There were no spasms, and the mouth could be opened a little further. Towards evening pain in the neck returned. On the 6th the general rigidity became more marked, and the teeth could scarcely be parted. The temperature was normal, and the pulse 100. A patch of herpes developed on the lower lip. The injection of magnesium sulphate was repeated.

On the following day the temperature rose to 100°, and fell again. During this and the next few days the rigidity became gradually less, and the spasm of the jaw diminished. The patient became able to say a few words consecutively, and was able to swallow custard on the 9th. On the 10th he complained again of pain in the neck, the jaw became stiffer, and there was one slight spasm. A third injection of magnesium sulphate was given. This was followed the next day by a rise of temperature to 101°, but the spasm and rigidity gradually diminished from this date, and no more attacks of spasm occurred. The pulse fell gradually. On September 13th 10 c.cm. of antitetanic serum were injected subcutaneously.

For about ten days there was severe headache, but this passed off, and the patient was allowed to get up on September 26th, and was discharged on October 3rd.

He has since remained in good health.

Remarks.

No septic focus was found when the patient was admitted, but the diagnosis of tetanus appears undoubted. Many cases of treatment by injections of magnesium sulphate into the subdural space have been recorded. Series of cases have been published from Egypt where the organism is much more prevalent than here. The results