might further reveal a general principle of value in determining the choice of antibacterial drugs for prophylactic or curative use, especially in virus infections.

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Note.—Since this essay was presented, the College of General Practitioners has begun a two-year investigation into the value of sulphonamides and antibiotics in the prophylaxis of the bacterial complications of measles. The conclusions reached in this essay were made available to the College, which hopes to obtain records of 2,000 to 3,000 cases of measles by the end of 1955.

THE EARLY DIAGNOSIS OF SPINAL TUMOURS

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The first patient to be successfully treated for spinal tumour was a British Army officer who was operated on by Sir Victor Horsley in 1887 (Gowers and Horsley, 1888). He recovered from paraplegia and lived for twenty years before he died from an unrelated condition. Since this demonstration that at least some spinal tumours were surgically accessible, and indeed curable, it has been of the utmost importance to diagnose such neoplasms early in their course and to locate them accurately.

It is not the purpose of this paper to describe in detail the established clinical syndromes, excellent accounts of which already exist (Elsberg, 1941). Rather is it intended to make use of the opportunity afforded the Service medical officer of having patients under observation from an early stage, and to comment on the clinical picture and diagnosis at this stage. Failure to make an early diagnosis may lead to incomplete recovery or even permanent disablement, despite the removal of a benign tumour, due to prolonged cord compression.

This paper is concerned with primary and secondary tumours which involve the spinal cord or nerve roots; such lesions develop in the vertebrae or in the structures within the spinal canal. The material for the investigation consists of 36 verified cases of spinal tumour treated between January, 1940, and December, 1951, at the Military Hospital for Head Injuries, Oxford. During this period there were approximately 1,150 admissions with spinal symptoms, 813 bearing the label of prolapsed intervertebral disk. These cases were drawn from the three Services and therefore represent a special cross-section of the population in regard to age and sex. There were 32 males and 4 females, the ages ranging from 17 to 60 years, 30 of them being under 35 years (see Table III).

Pathology

The lesions met with in this series are given in Table I. The frequency of the histological groups may be compared with those in a civilian series of 275 cases reported

TABLE I.—Pathology

Present Series		Civilian Series (Elsberg, 1941)	
Tumour	No. of Cases	Tumour	No. of Cases
Neurofibroma ..	15 (41.6%)	Meningioma ..	73 (26.5%)
Metastatic ..	8 (22.2%)	Neurofibroma ..	64 (23.2%)
Vascular ..	4 (11%)	Sarcoma ..	31 (11.2%)
Ependymoma ..	3 (8.3%)	Glioma ..	14 (5%)
Glioma* ..	3 (8.3%)	Metastatic ..	11 (4%)
Osteoclastoma ..	2	Ependymoma ..	14 (5%)
Melanoma ..	1	Vascular ..	9 (3.3%)
		Others ..	59 (21.5%)

* Two histologically unverified.

by Elsberg (1941). Table I reveals two important differences between the two series in the relative incidence of these tumours. There are no meningiomas and there is a high proportion of metastases in the military series. These points require further comment.

Meningiomas are found most often in middle-age, and when they occur in the spine women are affected twice as often as men (Learmonth, 1927); this group of patients not being represented in the section of the population from which our cases are drawn thus accounts for their absence in this series.

Metastatic tumours occurred in no less than 22% (8 out of 36) of the patients in this series, mainly young adults; the oldest patient with a secondary tumour was 42, four patients were in the thirties, one was 19, and two were 17 years of age. However, the incidence of metastatic spinal tumours is doubtless underestimated in civilian series based on statistics from surgical explorations: many overtly metastatic tumours, frequently presenting in the terminal stages of malignant disease, never reach the neurosurgeon. Nevertheless, it is important to appreciate that a metastatic neoplasm cannot be ruled out on age alone, nor on the apparent absence of a primary growth.

In six patients (Cases 29–34) the histological sections of the spinal tumour revealed secondary anaplastic carcinoma, suggestive of bronchial origin. Although the presence of a primary bronchial carcinoma was later confirmed by a post-mortem examination in only one instance (Case 34), the available facts favoured a bronchial origin for the primary growth in all six cases. Pulmonary or hilar shadows were present in four of the five patients in whom x-ray films were available.

Another patient with a secondary neoplasm (Case 35) died elsewhere, and a post-mortem examination revealed anaplastic secondary carcinomatous deposits in the spine, liver, lung, and iliac glands; a primary tumour was not found. The final patient in this group (Case 36) had vertebral collapse associated with a tumour in the lower end of the humerus, the radiological diagnosis being "osteogenic sarcoma"; no further information about the pathology is available.

The proved or probable bronchial origin of six of the eight metastases indicates the importance of x-raying the chest of every patient suspected of having a spinal cord tumour. A carcinoma of the lung may, however, remain clinically latent or not be apparent radiologically for some time in the presence of spinal metastases (see Case 31, described below). Occasionally the primary growth may be very small and be revealed only after a careful search at the post-mortem examination (Turner and Willis, 1938).

Although we have emphasized the frequency of metastatic growths it should be stressed that essentially operable and benign tumours were present in 40% of the Service cases and in 48% of the civilian series. It is in these cases that early diagnosis is so important.

Symptoms

With primary spinal tumours the symptoms usually have a gradual onset, preceding physical signs by many months. As some 70% of them are situated posteriorly or posterolaterally in the spinal canal it is natural that sensory should precede motor disturbances as a rule. Sphincter disorders usually occur later.

With secondary neoplasms, however, the course is characteristically rapid, paraplegia often developing within days of the first symptoms. In two cases in this series this interval was less than 10 days, whilst the longest history given by a case of secondary tumour was three months. All eight patients with metastatic lesions were unable to walk on admission, while this advanced picture was seen in only 6 of the 29 patients with primary spinal neoplasms. The rapid advance of some of these metastatic growths is illustrated by the following case.

Case 31. Extradural Metastatic Tumour with Three Weeks' History.—A trooper in the Life Guards, aged 17, was perfectly well until three weeks before admission, when he began to have backache. Pain down the right leg developed twelve days later, and three days before admission he rapidly developed a complete flaccid paraplegia below L4. Plain x-ray films of the spine showed only some doubtful erosion of the pedicle of D11, but lumbar puncture revealed a manometric block and a cerebrospinal fluid protein of 1,000 mg. per 100 ml.; myelography showed the block to be at D11. Laminectomy exposed an extradural tumour which was shown histologically to be a metastatic carcinoma, suggestive of bronchial origin. A chest x-ray film on the day of operation was clear. Later, supraclavicular, axillary, and intercostal glands became involved and a subcutaneous tumour which appeared over the scapula showed on biopsy the same appearances as had the spinal mass. The patient was transferred later to another hospital, where he was said to have developed cough and dyspnoea with signs of pulmonary collapse three weeks before his death, which followed three months after the laminectomy. A post-mortem examination was not made.

In contrast, the following case report illustrates the gradual onset of symptoms due to a benign spinal tumour.

Case 9. Dorsal Neurofibroma with Two Years' History.—An A.T.S. woman aged 26 first noticed numbness and a burning sensation in her right leg some two years before admission. For seven months she had experienced pain in the lower back and in both calves. During the four months before admission her gait had become increasingly unsteady, and for two months there had also been urgency and frequency of micturition. Examination revealed increased tone and weakness of the left leg, a sensory level at D8, and bilateral extensor plantar responses. A spinal x-ray film showed erosion of the pedicle and scalloping of the body of D7. Lumbar puncture revealed an almost complete spinal block and a cerebrospinal fluid protein of 120 mg. per 100 ml. She made a good recovery following removal of neurofibroma attached to the left seventh dorsal nerve root.

Pain is the commonest symptom, but it is not a constant feature. It occurred in 29 cases of this series (81%), which agrees with the findings of Craig (1936), who recorded pain as being present in 80% of 300 cases from the Mayo Clinic. Not uncommonly, and especially with tumours of the cauda

equina, there may be partial or complete temporary remissions of this symptom. Such remissions were found in five of our nine cauda equina tumours, and Allen (1930) reported remissions in 25% of 69 patients with tumours in this region.

Two types of pain are experienced: root pain and dull central backache. Root pain, which is the more common, was a manifestation in 24 of our cases (66%), and in 19 patients (53%) it was the initial symptom. That root pain is not confined to extramedullary tumours was pointed out as long ago as 1914 by Pearce Bailey. Indeed, such pain was found in nearly half the intramedullary growths studied by Kernohan and his colleagues (1931). In two of the five intramedullary tumours in the present series there was root pain, but in each case motor symptoms had preceded this by many months.

Root pain has certain characteristics. It may be aching or lancinating, is referred to the appropriate dermatome, and may be so severe as to require morphine for its relief. It is often accentuated, and sometimes precipitated, by raising the intrathecal pressure, as by straining and coughing; this is probably due to an alteration in the relationship of the tumour to near-by roots. It may be worse at night and be relieved by walking about or sleeping in a chair. Eaton (1941) suggests that this may be due to the lengthening of the spine which he has demonstrated experimentally to occur in recumbency. It is thought that the disks increase in thickness on lying down and that this is responsible for the pain by altering the relationship between the roots and surrounding structures.

Dull backache is common as a symptom of cauda equina tumours, but so frequently is this a complaint of other disorders that few sufferers should be suspected of having a spinal tumour on this account alone. It is backache which persists and fails to respond to rest that should arouse suspicion. Moreover, in the presence of a spinal tumour it is commonly accompanied by root pain; in only 4 of the 22 patients with backache in the present series was this the only type of pain. Though most constant in cauda equina tumours, backache is often a distressing feature of metastatic deposits in the vertebrae. It may even occur in intramedullary tumours, as evidenced by two patients in this series.

Pain was not a feature in seven patients (19%). This agrees with the figure of 20% reported by Craig (1936) and of 25% by Spurling and Mayfield (1936). The type of lesion present in our cases without pain varied, but included three examples of vascular malformation. There were two neurofibromas, one extradural secondary carcinoma of the bronchus, and one intramedullary tumour.

In other cases sensory disturbances apart from pain may be predominant, such as a sensation of tingling, pins-and-needles, burning, or numbness. These are common as early manifestations which occasionally occur alone, but more frequently are associated with backache and root pain.

Loss of power usually follows sensory disturbances, but it may occur as an initial symptom, and this is especially likely to happen with intramedullary tumours. In three of our cases this led to a diagnosis of poliomyelitis.

Sphincter Disturbance.—Although complete retention or incontinence of urine or faeces is a late manifestation, increasing constipation or some difficulty in micturition is not an uncommon symptom in patients with spinal tumour. Apart from 10 paraplegic patients who had incontinence or retention on admission, nine patients had experienced some difficulty in micturition, but in none was this a presenting feature.

Physical Signs

The presence of suspicious symptoms, such as root pain and persistent backache, warrants a thorough examination of the whole patient. In the majority of cases with spinal tumour this will yield further evidence of such a lesion. The *spine* is tested for local tenderness or deformity, muscle spasm, and limitation of movement. Spinal tumours in the lumbar region—that is, of the cauda equina—commonly

produce erector spinae spasm, a stiff spine, and even scoliosis. The range of straight-leg raising and the effects of jugular compression and of coughing are recorded. Careful examination of the *nervous system* will often indicate the level of the lesion fairly accurately, especially if the patient is paraplegic. Weakness, wasting, reflex changes, and sensory loss all contribute to this localization. The *general examination* should include in particular a search for the cutaneous pigmentation or tumours of neurofibromatosis and for angiomas of the skin or retina; and palpation of the abdomen, rectum, and breast for evidence of primary malignancy. The chest is x-rayed for primary or secondary neoplasms and to visualize any thoracic extension of dumb-bell tumours of the spine.

Dandy (1925) claimed that over 90% of tumours could be both diagnosed and located in this way, but he was referring to the established picture. Such signs may be minimal if the patient is seen at an early stage, and indeed in some cases when special investigations give definite evidence of a tumour. These investigations normally consist of plain x-ray films of the spine, lumbar puncture, and myelography. There were five cases in this series with minimal signs, and they are mentioned later in relation to the differential diagnosis from prolapsed intervertebral disk, which they all closely resembled. One may be noted here as an example.

Case 4. Neurofibroma of the Cauda Equina with Minimal Neurological Signs.—A major aged 60 complained of pain in the left buttock and thigh, accentuated by coughing and sneezing, for eleven months. He had massage and short-wave diathermy, following a diagnosis of fibrositis and osteoarthritis. Six weeks before admission he developed low lumbar pain. There was no weakness or sensory or sphincter disturbance even to direct questioning. The only signs on admission were a stiff lumbar spine, a slight depression of the left knee-jerk, and slightly impaired sensation, to pin-prick only, on the outer side of the left thigh. A preliminary diagnosis of prolapsed intervertebral disk was made. Plain x-ray films were normal, but a lumbar puncture showed a cerebrospinal fluid protein of 360 mg. per 100 ml., and myelography suggested a possible tumour at L 4. At operation a neurofibroma was removed from the left side of the cauda equina. He made a good recovery.

Though not a feature of any of our cases there may be no physical signs whatsoever, even when investigations reveal a tumour (Cohen and Kaplan, 1943; Toumey *et al.*, 1950). In all these reported cases, together with the five patients in this series with minimal signs, the tumour was situated in the cauda equina. Here the bony canal is relatively roomy, and this may be the explanation for the paucity of signs.

Ancillary Investigations

Radiography

Plain X-ray Films.—In 16 cases (44%) plain x-ray films of the spine showed appearances suggestive of spinal tumour. There may be gross vertebral destruction (three cases), but, more frequently, less well-marked changes occur such as erosion of the pedicles and laminae (10 cases), widening of the intervertebral foramina (three cases), and scalloping of the posterior aspect of the vertebral bodies (three cases). The value of such films is obvious, and in addition the changes produced by a primarily vertebral tumour or other spinal disease may be revealed.

Myelography, using ethyl iodophenylundecylate ("myodil"), was employed in the final localization of the tumour in 22 cases. Although myelography is by no means always necessary for the detection of a spinal tumour, it is invaluable in accurate localization, and may be the only way in which a neoplasm can be excluded in suspicious cases. Owing to oedema and secondary vascular effects the clinical level may be false, and at the best the clinician has only clues concerning the extent of the lesion. The myelogram may also suggest whether the neoplasm is intramedullary or extramedullary, the longitudinal extent of the lesion, or the presence of multiple tumours. It also gives the surgeon the opportunity to mark the lesion in relation to the spinous processes pre-operatively and so render exposure more precise.

Lumbar Puncture

This procedure revealed an abnormality in every case in the present series. The changes were partial or complete manometric block, xanthochromia, and raised cerebrospinal fluid protein, though all three features were not always present.

Manometry.—Partial or complete manometric block was found in 26 of our cases (76%). So important is the detection of spinal block that manometry must be carefully carried out in every case. In patients with suspected tumour it has been our practice, where possible, to have two observers—one to apply bilateral jugular pressure and the other to watch the manometer. First, light compression of the neck is applied, as this may reveal an incomplete block, past which fluid could be driven by firm compression (Stookey *et al.*, 1925); normally a rise of 10–30 mm. is to be expected at this stage. Then firm pressure is applied for ten seconds, and this should, in the absence of a block, produce a steady rise up to 300 mm. with a more rapid fall on release. If there is a complete block there will be no rise at all, whilst any definite delay in either the rise or the fall indicates an incomplete obstruction. The application of a sphygmomanometer cuff to the neck with the pressure raised to approximately 80 mm. may be used as an alternative to manual jugular compression.

The patient must be warned to relax during the manometry, and in particular reassured about the neck compression, since if, as is natural, he reacts to it by holding his breath and tensing his abdominal muscles, this alone will produce a rise in the manometer reading even in the presence of a complete block. If no obstruction was demonstrable at the beginning of the test then manometry should be repeated after the removal of a few millilitres of fluid for analysis, before the needle is withdrawn.

It has been shown experimentally by Poppen and Hurxthal (1934) that manometric abnormalities are not to be expected until the diameter of the remaining patency of the spinal subarachnoid space is less than the diameter of the lumbar puncture needle used. Occasionally a block will be evident only after the removal of fluid, possibly due to the meninges collapsing down on to the tumour (Ayer, 1920). Repeated dry taps suggest obliteration of the subarachnoid space by a large cauda equina neoplasm; the needle may have entered the neoplasm.

Cerebrospinal Fluid Protein.—The cerebrospinal fluid was examined in 35 cases, and all showed a rise of protein from 50–6,000 mg. per 100 ml. (upper limit of normal taken to be 45 mg. per 100 ml.). Of the four cases with slight increases only (50–65 mg.), three had manometric evidence of block, so that the significance of the slight abnormality was not likely to be overlooked. Whilst the increase in protein is usually the result of a spinal block, it may occur in the absence of such obstruction, and is then thought to be due to exudation from the surface of the tumour. Raised protein from this cause may thus be found in those cases of cauda equina tumour in which the cerebrospinal fluid is withdrawn above the site of the neoplasm. Of the nine cauda equina tumours reported here, five were associated with over 1,000 mg. of protein per 100 ml.

Xanthochromia.—This was present in 16 of the 29 cases in which the appearance of the fluid was recorded. Whilst usually associated with a very high protein, whether below a block or above a cauda equina tumour, there was one case with xanthochromia but only 110 mg. of protein per 100 ml., and two others with 150 mg.

Cells.—In most patients there was no increase of cells in the cerebrospinal fluid, but in seven cases a slight increase in lymphocytes was reported (7–12 per c.mm.). This feature gave no hint of the type of lesion present, since it was found in cases of neurofibroma, angioma, glioma, and secondary carcinoma.

In view of the obvious diagnostic value of lumbar puncture, the question arises of how readily, or at what stage, should one recommend it. Two factors influence the

decision. The first is the appreciation that a spinal block may exist, due to a tumour, when neither plain x-ray films nor clinical examination of the central nervous system have shown any abnormality—or nothing diagnostic (see Case 20, described below). The second is the possible risk of the procedure, fear of which may dissuade investigators outside special units from pursuing their cases to this vital stage. During the past two years in this hospital over 2,000 diagnostic lumbar punctures have been performed safely without sequelae other than headache in a few cases. However, there are some cases reported from time to time of the precipitation or aggravation of the neurological signs after puncture in cases of spinal cord tumour. Because of this possibility, Horrax (1947) has suggested that lumbar puncture should be carried out in cases of suspected cord tumour only when there are facilities for proceeding, if necessary, to immediate laminectomy.

From a survey of our own experience and of cases in the literature, we think that the risk of lumbar puncture has been exaggerated, with the important exception of cervical cord tumours in which puncture may precipitate respiratory paralysis. In such suspected cases, and also in rapidly progressive cases, it is advisable to postpone this examination until the patient is in a special unit. Apart from these instances, we hold the view that if a patient complains persistently of backache or root pain for which there is no obvious cause, and the films of the spine are normal, a lumbar puncture should be performed, as this may be the only way by which a spinal tumour may be excluded with confidence. So common are these symptoms, and so uncommon are spinal tumours, that there clearly will be numerous investigations of this kind which will come to nothing, and it would be quite impracticable to restrict lumbar punctures to neurosurgical units.

The value of lumbar puncture is exemplified in Cases 3 and 20.

Case 3. Neurofibroma of the Cauda Equina; Minimal Neurological Signs.—A flying officer aged 22 gave a history of an attack of left-sided sciatica aggravated by coughing for a period of a fortnight, nine months before admission. The pain recurred during a bumpy car journey three months prior to admission, and two days later he went to bed for an unrelated condition (duodenal ulcer). While in bed the left-sided sciatica became worse, and a month before admission he also developed sciatic pain on the right. On examination he walked stiffly and there was slight weakness in both legs. No sensory loss was demonstrated and the reflexes were symmetrically brisk. Straight-leg raising was reduced to 20 degrees on each side. Plain films were normal, but lumbar puncture revealed partial block with xanthochromic fluid containing 950 mg of protein per 100 ml. A myelogram showed a block at L1. A cystic neurofibroma was removed from the cauda equina and he made a good recovery.

Differential Diagnosis

It is clear that in most cases the diagnosis of an intraspinal lesion is easy once the suspicion is aroused, although its exact nature may require special study. However, it will be apparent from the symptomatology that in the earlier stages, and in other cases in which neurological abnormalities remain minimal, a spinal tumour may readily be confused with other conditions. Some of the difficulties are well exemplified in the Services, where in general the patients come under medical observation early.

The average delay between first consulting a doctor and undergoing operation was 6.4 months in the present series. On the other hand, reports from civilian centres point to much longer delays; in one series the corresponding interval was seventeen months (Van Wagenen and Rossier, 1938). Specialist medical advice is particularly easy of access in the Services, and this probably accounts for the shorter delay. Late operations are due largely to the multiplicity of common conditions (see Table II) which can give rise to the same types of pain, and to the considerable rarity of spinal tumours. Added to this is the not infrequent paucity of abnormal signs in the central nervous system even in many long-standing cases. In the majority of cases there is

TABLE II.—Some Incorrect Diagnoses in 28 Patients

Diagnosis	Cases
Fibrositis, rheumatism	10
Prolapsed disk, sciatica, neuritis	10
Functional, hysteria, neurosis	9
Disseminated sclerosis	5
Tuberculous spine	4
Poliomyelitis	3
Peripheral neuritis	2
Syringomyelia	2
Subacute combined degeneration	1
Neurosyphilis	1
Cervical rib	1
Renal colic	1
Peptic ulcer	1
Total	50

for some time no specific neurological disability to draw attention to the central nervous system, whilst even in retrospect it is difficult to discern any single characteristic of the pain complained of, other than its persistence, that should have led to the suspicion of a spinal tumour as its cause. In short, we wish to stress that there is often a period of many months in the natural history of a spinal tumour when confusion with other conditions may readily arise, with consequent delay in surgical treatment.

Late diagnosis may prove disastrous to the patient with a benign spinal tumour. Irreparable damage may occur either from prolonged compression of the cord or from interference with its blood supply, so that even if a total removal is still possible recovery is slow and perhaps incomplete.

Although the possible differential diagnoses are legion certain conditions are more commonly simulated than others.

Prolapsed Intervertebral Disk

This diagnosis was made at some stage in 10 cases of the present series. The five patients already mentioned with minimal signs in the central nervous system closely simulated disk lesions, and two of them have been described (Cases 3 and 4). A further example illustrates the difficulty in diagnosis (Case 20).

Case 20. Ependymoma of the Cauda Equina Resembling Prolapsed Intervertebral Disk.—A man aged 28 had attacks of back pain for twelve months before operation. These would last five or six days and resolve with physiotherapy. A month before operation right-sided sciatica complicated an attack and he came into hospital. His pain increased in bed, but the only abnormal physical signs were flattening and rigidity of the lumbar spine and slight scoliosis, straight-leg raising was limited to 60 degrees bilaterally and there was a doubtful depression of the knee- and ankle-jerks on the right. In this hospital the diagnosis after x-ray examination, but before lumbar puncture, was of prolapsed intervertebral disk, as had been thought elsewhere. Further investigation showed, however, a complete spinal block and xanthochromic fluid containing 2,500 mg. of protein per 100 ml. A myelogram revealed a block at L1, and at operation an ependymoma of the cauda equina was partially removed.

Two not infrequent features of tumour cases may render the simulation of the disk syndrome very close: (1) Temporary remissions of pain, which may even coincide with treatment applied for a supposed disk lesion and so be taken as confirming the suspicion. (2) Signs of disordered spinal mechanics—stiff spine with diminished straight-leg raising.

Although in most cases the history and evolution of the clinical picture are quite different in the two conditions, in some cases it may be impossible to make the distinction clinically, and Case 4 shows the value of lumbar puncture in settling the problem. Lumbar puncture is not everywhere a routine procedure before disk surgery is undertaken, but it would seem to be a wise precaution in the light of this experience. It has always been the practice in this centre.

"Backache"

There were 10 cases diagnosed at some stage as "fibrositis" or "rheumatism"—that is, non-articular rheumatism—on account of the complaint of backache alone. One of the cases (Case 20) had attacks of backache as the only symptom for eleven months, and, furthermore, these bouts

TABLE III.—Service Patients with Spinal Tumours

Case No.	Sex and Age	Duration of Symptoms	Main Symptoms	State on Admission	Lumbar Puncture			Plain X-ray Spine	Pathology
					Colour	Block	Protein mg./100 ml.		
1	M 32	8 years	Back and root pain (sciatic)	Minimal signs	Y	B	6,000	+	Neurofibroma, cauda equina
2	M 27	11 months	Back and root pain (to testicle)	Slight weakness left leg	Y	B	1,600	—	" " "
3	M 22	9 "	Back and root pain (sciatic)	Minimal signs	Y	P.B.	950	—	" " "
4	M 60	11 "	" " "	" " "	N	Reproduced pain	360	—	" " "
5	M 20	9 "	Neck pain and weakness of all limbs	Tetraplegia	Y	P.B.	3,000	—	Neurofibroma, C1-2
6	M 22	5 "	Weakness right leg	Mild paraparesis	?	P.B.	50, later 70	+	" " "
7	M 26	7 "	Back and root pain (to chest). Weakness legs	Paraplegia	Y	B	4,200	—	Neurofibroma, T 12
8	F 22	2½ "	Back and root pain (to both calves)	Slight weakness left leg	N	P.B.	960	—	Neurofibroma, T 7
9	F 26	22 "	Neck and root pain (to shoulder). Weakness all limbs	Tetraparesis	?	P.B.	120	+	" "
10	M 19	3½ "	Root pain (sciatic)	Weakness right leg	N	B	55	+	Neurofibroma, C 5
11	F 31	6 "	Numbness and weakness legs	Mild paraparesis	Y	B	1,200	+	Neurofibroma, cauda equina
12	M 28	16 "	Root pain (to abdomen). Weakness of legs	Flaccid paraplegia	N	B	65	+	Neurofibroma, C 7-T 1
13	M 36	13 "	Weakness legs	Paraparesis	Y	B	1,000	+	Neurofibroma, T 9
14	M 19	3 "	Progressive weakness all limbs	Paraplegia	?	B	130	—	Neurofibroma, T 6-7
15	M 23	6 "	Weakness leg	Weakness leg	Y	N	300	—	Neurofibroma, cervical
16	M 45	3 years	Root pain (to abdomen)	Weakness leg	N	P.B.	200	—	Angioma, cervical
17	M 24	22 months	Numbness and weakness legs	Mild paraparesis	Y	N	150	—	Angioma D 12
18	M 60	18 "	Back and root pain (sciatic)	Flaccid paraplegia	N	N	80	—	Angioma D 9-11
19	M 33	5 "	Minimal signs	Minimal signs	N	N	220	—	Angioma D 10-11
20	M 28	12 "	Weakness legs	Weakness legs	Y	B	2,500	—	Ependymoma cauda equina
21	M 29	7 "	Back and root pain (sciatic)	Paraparesis	Y	N	150	—	" " "
22	M 20	7 "	Back and root pain (sciatic)	Paraplegia	Y	B	Clotted	+	" " "
23	M 23	2 "	Weakness legs	Weakness legs	Not done			+	Osteoclastoma L 4
24	M 19	8 "	Back and root pain (to chest)	Mild paraparesis	N	N	80	+	Osteoclastoma D 8
25	M 36	5 "	Weakness legs	Paraplegic	N	B	80	—	" Intramedullary tumour " D 10-12
26	M 31	8 "	Back pain. Weakness leg	Weakness leg	N	N	55	+	" Intramedullary tumour " D 3
27	M 22	3 "	Back pain. Weak legs	Paraplegic	Y	B	2,000	—	Spongiosblastoma D 2-3
28	F 22	7 "	Neck pain	Mild tetraparesis	Y	N	110	—	" Primary malignant melanoma " C 3 root
29	M 35	3 weeks	Back pain. Weak legs	Paraplegic	N	B	300	—	Anaplastic secondary car. D 4. ? Bronchogenic
30	M 17	9 days	Root pain (to chest). Unable to walk	"	N	B	200	+	Anaplastic secondary car. D 1-3. ? Bronchogenic
31	M 17	3 weeks	Back and root pain (to leg)	"	?	B	1,000	+	Anaplastic secondary car. D 12 ? Bronchogenic
32	M 19	5 "	Root pain (to chest and arms). Unable to walk	"	Y	P.B.	240	+	Anaplastic secondary car. C 7. ? Bronchogenic
33	M 42	3 months	Back and root pain (to chest). Weakness legs	"	Y	B	350	—	Anaplastic secondary car. D 10. Bronchogenic
34	M 30	10 days	Unable to walk	"	?	P.B.	120	—	Secondary car. D 7-10. Bronchogenic (P.M.)
35	M 31	3 weeks	Back and root pain (to thighs). Unable to walk	"	N	B	150	+	Secondary car. D 7. Unknown primary (P.M.)
36	M 35	7 "	Back and root pain (to legs). Weak legs	Paraparesis	?	B	600	+	" Secondary osteogenic sarcoma " D 8

Y=Yellow. N=Normal. B=Block. P.B.=Partial block. +=Abnormal. --=N.A.D. P.M.=Post Mortem

responded to physiotherapy. Case 1 illustrates that a long history cannot exclude tumour even when pain in the back remains the principal complaint.

Backache, especially if there is restricted spinal movement with muscle spasm, may raise the possibility of disease of the spine itself such as tuberculosis, ankylosing spondylitis, and osteoarthritis. A plain x-ray film usually disposes of these diagnoses.

Case 1. Neurofibroma of Cauda Equina—Prolonged Complaint of Backache without Neurological Disability.—A man of 32 was admitted in 1943 with a history of intermittent backache since 1935, when he had fallen, injuring his back. On that occasion he recovered after three weeks in bed, but two months later backache recurred and pain radiated down the left leg into the calf. There was no relief of symptoms in spite of five months in hospital, and he returned to work. In 1940 he joined the Army and, although able to manage a twenty-five-mile route march, he could not do physical training, and in 1942 "collapsed" with pain in his back during an assault course. Examination in hospital on several occasions did not reveal any obvious organic causes. On admission here he complained of backache and pain down the left leg which was continuous and aggravated by coughing. There were no other symptoms. Examination showed minimal sensory loss over the lateral aspect of the left thigh, slight diminution of the left knee-jerk, and an abnormal plantar response; no weakness could be detected. Straight-leg raising was normal, but jugular compression aggravated the pain. There was spasm of the erector spinae muscles with some limitation of spinal flexion. X-ray examination of the spine revealed

some flattening of the pedicle of L3. Manometry demonstrated a complete spinal block, the cerebrospinal fluid being yellow and containing 6,000 mg. of protein per 100 ml. Myelography showed a complete obstruction at the level of L3. At operation, eight years after the onset of symptoms, a neurofibroma was removed from the third left lumbar nerve root. He made a good recovery.

In this story there was nothing about the pain, apart from its persistence, which was suggestive of a tumour. The neurological signs, even after eight years, were not gross.

Visceral Diseases in the Thorax or Abdomen

Root pain is produced by many types of visceral disease, and this pain may be indistinguishable from that produced by irritation of the same roots by spinal neoplasm. Not uncommonly, abdominal operations of varying severity have been carried out for persistent pain before the correct diagnosis of spinal tumour has been made (Spurling and Mayfield, 1936; Craig, 1936).

Case 2. Neurofibroma of the Cauda Equina Resembling Visceral Disease.—An Army driver aged 27 had increasing pain in the left loin, radiating to the testicle and the front of the thigh, for eleven months; the pain was accentuated by coughing. It was thought to be of renal origin, but when intravenous pyelogram and urinary examinations were repeatedly negative he was referred to a psychiatrist, who diagnosed prolapsed intervertebral disk. The patient was transferred to this hospital, where examination showed slight weakness and depression of reflexes in the left leg and some diminution of sensation below L1 segment.

Lumbar puncture revealed a complete spinal block and a yellow fluid containing 1,600 mg. of protein per 100 ml. Myelography confirmed the block, and removal of a neurofibroma from the second lumbar nerve root completely relieved the symptoms.

Non-neoplastic Diseases of the Spinal Cord

In a few cases of neurological disease such as disseminated sclerosis, poliomyelitis, transverse myelitis, and motor neurone disease, clinical examination may suggest a focal spinal lesion, and if the cerebrospinal fluid protein is elevated the presence of a tumour may be suspected. It is in such cases that resort to myelography may be necessary. There were no cases in the present series in which a diagnosis of disseminated sclerosis was made after admission to this hospital. However, this is a common initial diagnosis in spinal cord lesions, and in these cases a lumbar puncture should always be carried out.

The importance of examining the blood and cerebrospinal fluid for the Wassermann reaction may be mentioned here; in relation to this it is interesting to remember that the original description of the Froin syndrome probably referred to three cases of syphilitic meningomyelitis (Greenfield and Carmichael, 1925).

Extradural Abscess

This is commonly simulated only by metastatic tumours, but the resemblance can be close. In this series three of the eight metastatic tumours were initially thought to be extradural abscesses, and emergency laminectomy was performed in one case (No. 34).

Case 34. Extradural Metastasis Resembling Extradural Abscess.—A man of 30, who had been treated for secondary syphilis three months previously, developed increasing weakness of the legs over three days. Examination showed a spastic paraparesis with pyramidal reflex changes, and a diagnosis of syphilitic meningomyelitis was made. Spinal x-ray films were normal, but a lumbar puncture showed a partial block with 120 mg. of protein per 100 ml. and 5 cells per c.mm. Paraplegia was rapidly progressing, and a neurosurgeon was consulted. A diagnosis of extradural abscess was made and an emergency laminectomy performed. A mass of pathological tissue was found extradurally which was said to be suggestive of a healing abscess, both macroscopically and microscopically. Two months later chest x-ray examination showed a hilar mass; only "congestive changes" at one base had been seen on a film a week before operation. Death occurred three months after laminectomy, and post-mortem examination showed a primary bronchial tumour with widespread secondary deposits, including those in the spinal dura.

These cases, then, illustrate the difficulties besetting the clinician confronted with a patient suffering from a spinal tumour. Two points emerging from a study of this series are, firstly, the value of lumbar puncture, and, secondly, the necessity for exploring the possibility of an intraspinal lesion in puzzling cases of backache or root pain and of periodic examination of the nervous system in search of minimal signs.

Treatment

Laminectomy should be carried out as soon as the diagnosis is established and the location determined. Complete removal of the tumour is, of course, the ideal procedure and is usually possible in cases of neurofibroma. Of the 14 neurofibromas operated on in this series all were totally resected and 11 made a complete recovery. The only unoperated case in the whole group was that of a dumb-bell fibroma with a large extraspinal mass in the neck, and the patient succumbed within nine weeks of admission (Case 15). The remaining tumours were only partly removed or else were left with decompressions, and the majority were then treated with radiotherapy. Incomplete removal followed by radiotherapy gave a satisfactory immediate recovery in two cases of ependymoma of the cauda equina. There was one operative death due to aspiration pneumonia. No long-term follow-up has been possible.

Conclusions

Spinal tumours in their early stages often present a difficult diagnostic problem. This is partly because the presence

of such a lesion may not be even thought of owing to its comparative rarity, and partly because it may simulate other more common disorders for many months or even years before there is total cord compression.

A variety of conditions may be confused with spinal tumour, the most frequent being "rheumatism," prolapsed intervertebral disk, neurosis, disseminated sclerosis, and visceral disease within the thorax or abdomen. However, a careful evaluation of the type of pain and a full neurological examination will in most cases of spinal tumour suggest the possibility of such a lesion. Furthermore, diagnosis is often possible, at a stage when neurological signs are minimal or debatable, by performing a lumbar puncture. Less often, plain x-ray films of the spine lead to detection.

Surgical treatment is often completely curative, but only if the diagnosis is made before irreversible pressure changes have occurred in the cord or nerve roots.

Summary

Service patients tend to come under observation early, and this opportunity has been taken to comment on the early clinical picture and diagnosis of spinal tumours based upon a study of 36 cases at the Military Hospital for Head Injuries, Oxford.

The average delay between the first consultation and operation was 6.4 months, which is shorter than in most civilian series. Common diagnostic errors were "fibrositis" or "rheumatism" in 28% of cases, prolapsed intervertebral disk or "sciatica" in 28%, and "neurosis" in 25%.

The most frequent complaint was backache and/or root pain, occurring in 81% of cases; in 61% it was the initial symptom. In five cases there were only minimal or doubtful neurological signs, although pain had been present for nine months or more.

The most frequent neoplasm was the neurofibroma (41%). An unexpectedly large number of metastatic tumours was present (22%), most of which appeared to be of bronchial origin; three of these tumours occurred in patients between 17 and 19 years of age. A metastatic lesion should be suspected if the history is short and the clinical picture advanced.

Reference is made to the ancillary investigations, and attention is drawn to the value of lumbar puncture in early diagnosis, especially in doubtful cases. Evidence of spinal block was obtained in 76% of cases, and in all 35 patients whose cerebrospinal fluid was examined the protein content was raised.

Lumbar puncture may be the only way of excluding a tumour with any confidence in patients with persistent back or root pain for which there is no obvious cause. The possible dangers of the procedure are negligible, except in rapidly progressive cases and those with suspected cervical tumours, the investigation of which should be delayed until neurosurgical aid is available.

We are indebted to the medical officers responsible for the detailed clinical notes, often made under considerable wartime difficulties, without which this study could not have been possible. We have received much encouragement from members of the staff of the Nuffield Department of Surgery, Oxford, and are particularly grateful to Mr. Joe Pennybacker for suggestions and to Dr. Peter Daniel for help with some of the pathological data. Above all, our gratitude is due to Mr. Walpole Lewin for much helpful advice and criticism at all stages in the preparation of this paper. We wish to thank the War Office for permission to publish these cases.

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COARCTATION OF THE AORTA AND PREGNANCY

REPORT OF FIVE CASES

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Coarctation of the aorta is an uncommon finding in adults and shows its higher incidence in males in a proportion of 3 males to 1 female (Abbott, 1928). The association of this anomaly with pregnancy must therefore be of some rarity. Benham (1949) was able to find records of only 53 cases in the literature and added three personal reports. To these can be added the following cases: Dieckmann (1941), 4; Magnin (1944-5), 1; Novak (1947), 1; Clark and Koenig (1947), 1; Cohen (1949), 1; Marcorelles (1949), 1; Money (1949), 1; Sundfjør (1950), 3; Vander Veer and Kuo (1950), 2; Brown (1950), 4; Greig and Parker (1951), 1; Bond (1951), 1; Kerr and Sodeman (1951), 5; Soulié *et al.* (1951), 3; Notter (1952), 1; Miller and Falor (1952), 2; Stéphan (1952), 1; Peterson *et al.* (1953), 1; and Taylor and Pollock (1953), 1; making a total of 91 recorded cases.

In view of the infrequency of pregnancy complicating coarctation of the aorta the assessment of the risks involved and the prognosis and management of any individual patient become considerations of great importance and difficulty for the physician and obstetrician whose experience of this association of conditions must necessarily be limited. It would seem desirable that as many records as possible be reported so that a firmer basis for judgment may be provided. With this in view the following five cases are reported.

Case 1

The patient, aged 25, was referred from the local antenatal clinic at the third month of her first pregnancy for the diagnosis of a suspected heart lesion. A "rheumatic heart" was said to have been discovered when she was 5 years old, and from about the age of 10 she had had symptoms very suggestive of mild intermittent claudication. These lasted on and off for about five years. The only symptom of note after this had been mild dyspnoea on exertion, which she thought was probably a little more prominent since the beginning of her pregnancy. Except for this and very occasional "bilious attacks" (vomiting, mild headaches, but no eye symptoms) she was perfectly fit and well.

Examination showed the classical signs of coarctation of the aorta. Blood-pressure readings were: right arm, 170/100; left arm, 150/95; right leg, 120/100; left leg, 115/90. The heart size was within normal limits. She had a mild ichthyosis, mostly involving the skin of the trunk, upper arms, and thighs, and this had been present since childhood. She had no other abnormal physical signs. X-ray examination of the chest showed a poorly developed aortic knuckle and notching of the third, fourth, sixth, seventh, eighth, and ninth ribs of both sides. Blood counts, blood urea, and Wassermann reaction were normal. Intravenous pyelography studies and an electrocardiogram were within normal limits. The amylobarbitone test resulted in an average blood pressure of 130/95 compared with 155/100 before the test.

She attended the medical clinic regularly and the pregnancy proceeded uneventfully. At the 27th week a slight generalized enlargement of the thyroid gland was noted. She was admitted to hospital at the 36th week for a final rest prior to confinement. One week later she began to complain of nausea, hot flushes, palpitations, and precordial pain. Over the course of three hours her pulse rate rose from 80 to 115 a minute, the systolic blood pressure from 135 to 165 mm. Hg, and the diastolic pressure from 95 to 100 mm. Hg. It was decided to perform caesarean section at once. The lower segment operation was done under spinal analgesia, and a living infant weighing 5 lb. 6 oz. (2.4 kg.) delivered. The patient was not in labour and there was much bleeding from the thickened lower segment of the uterus. It was noted that the abdominal aorta was half normal size. The puerperium was uneventful, and she was discharged from hospital after three weeks.

The patient was seen again at the medical clinic three months later. She had remained fit and well with no complaints except for slight dyspnoea on exertion, which was no worse than before the pregnancy. There were no notable changes in the physical signs. She remained in good health for five months after delivery. One night, about one and a half hours after going to bed, she awoke, told her husband she felt "queer," rapidly became unconscious, and died within half an hour. A post-mortem examination was not carried out.

Case 2

A primipara aged 21 was referred from the local antenatal clinic for diagnosis of a suspected heart lesion. She had had no serious illnesses as a child and had played games and cycled as other girls of her age. She had no complaints of headaches or pains in the legs. Eighteen months previously she had been off work for three months with dyspnoea on exertion, lethargy, and ankle oedema. These symptoms returned when she became pregnant, but on stopping work she regained her former good health.

On examination she was found to be 20 weeks pregnant. The blood pressure in the arms was 165/85 mm. Hg, and the systolic pressure in the legs, by palpation of the dorsalis pedis artery, 105 mm. Hg. A systolic murmur could be heard at the base of the heart at the level of the second rib on the left side close to the sternum. A loud systolic murmur was heard over the whole posterior chest, maximal in the mid-zone on both sides. A systolic thrill was felt in the left supraclavicular region. X-ray examination showed the heart to be normal in size and configuration, though the aortic knuckle was not seen. Rib notching was not present.

The pregnancy continued uneventfully until the thirty-eighth week, when she was admitted with uterine haemorrhage. A central placenta praevia was diagnosed and a living infant of 5 lb. 14 oz. (2.7 kg.) delivered by lower segment caesarean section. No note was made of the size and pulsation of the abdominal aorta. Except for a mild pyrexia and anaemia the puerperium was normal. On the tenth day the cardiac bruits were unchanged. No collateral circulation could be felt or seen. The blood pressure in the arms was 150/75 mm. Hg, while that in the legs could not be determined. The femoral artery pulsations were not felt.