To demonstrate this the following technique was used. An all-glass 2-ml. syringe with a No. 23 needle attached was filled with normal saline and a tiny drop of citrated blood (as used for estimation of sedimentation rate by the Westergren method) was placed on the tip of the needle by means of a Pasteur pipette. After an interval varying from 15 to 60 seconds the needle was cut off at the socket with wire-cutters, the socket removed from the syringe, and the drop of saline on the tip of the syringe examined for red cells. It was found that contamination could occur in 45 seconds, as the results shown in Table VI demonstrate.

TABLE VI.—*Spread of Red Cells Along the Needle Towards the Syringe*

Time Interval between Application of Red Cells and Cutting the Needle	No. of Red Cells in 0.9 c.mm. of Saline in Drop at Tip of Syringe				
	Expt. 1	Expt. 2	Expt. 3	Expt. 4	Expt. 5
15 secs.	0	0	0	0	0
30 "	0	0	0	0	0
45 "	0	4,608	396	0	0
60 "	780	0	0	13,392	13,392

Aspiration of Contents of Needle when it is Removed from the Syringe

That this actually occurs can be very simply demonstrated. A syringe with needle attached is filled with fluid and the plunger pressed until a small drop of fluid appears at the tip of the needle; if the needle is then removed from the syringe the drop is immediately sucked back.

Gross contamination of the syringe by this mechanism was demonstrated with a similar method. The syringe, with the needle attached, was filled with normal saline and a tiny drop of citrated blood was placed on the needle-tip; the needle was then removed from the syringe and the drop of saline at the tip of the syringe was examined for red cells. Contamination resulted, as can be seen in Table VII.

TABLE VII.—*Aspiration of Needle Contents on Removal from Syringe*

Size of Needle	No. of Red Cells in 0.9 c.mm. of Saline in Drop at Tip of Syringe		
	Experiment 1	Experiment 2	Experiment 3
23	105	Too numerous to count	Too numerous to count
21	Too numerous to count	14,544	" "
19	70,560	26,784	" "

Further experiments, which it is unnecessary to detail here, have shown that the amount of fluid which can be aspirated by this means may be as large as 0.1 ml.; this is more than the internal volume of the needles used. Hence it is probable that when the needle is removed from the syringe the whole of the contents of the needle (but not of the socket) are aspirated and replaced by air.

Discussion on Syringe Contamination

From the above experiments it is clear that in a high proportion of cases a syringe is contaminated after a single intramuscular injection of 1 ml. has been given. The limited number of investigations carried out suggests that contamination occurs as follows. A small amount of fluid is forced back into the needle after the injection, or traces of blood are left on the tip of the needle when it is withdrawn; this blood tends to spread slowly along the needle, and on removing the latter from the syringe the needle contents are aspirated, leaving a contaminated drop of fluid on the tip of the syringe. This drop contaminates the next injection despite the changing of the needle. It seems possible that in exceptional circumstances (and particularly when a large quantity is injected) fluid is actually forced from the muscle into the syringe and directly contaminates the syringe contents.

Summary

A series of cases of jaundice following penicillin treatment is reported. It is considered that this condition is transmitted from patient to patient by means of contaminated syringes.

Experiments are described which show that a single intramuscular injection of 1 ml. of fluid may lead to contamination of the

syringe used. The mechanism by which this contamination occurs is discussed.

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PYOGENIC OSTEOMYELITIS OF THE SPINE

BY

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Although pyogenic osteomyelitis of the spine is generally considered to be a rare and fatal disease, a perusal of the literature and a more ready appreciation of the possibility of the condition lead to the conclusion that it is considerably more common than was originally thought and that it is by no means so fatal as has been considered. Wilensky (1934) and Kulowski (1936) in the United States have described the condition well, and Turner (1938) in this country has added to our knowledge. It is agreed that osteomyelitis of the spine, forming part of a generalized bacteraemia, has been almost invariably fatal, and Butler *et al.* report a mortality of 100% in 13 cases, all occurring in children and young adults. It may be that penicillin will brighten this gloomy picture.

These cases are often so acute and fulminating that an ante-mortem diagnosis is not made owing to the intense toxæmia of the patients; the more hopeful variety of the disease is that where the pathology is limited to one or other region of the spine, and in these cases the mortality rate is somewhere in the region of 25%. There is reason to suppose that cases labelled tuberculosis of the spine, which do so well with an early firm bony fusion, are in reality cases of pyogenic osteomyelitis, as will be discussed later, and when these cases are recognized it may be that the mortality is even lower.

The disease is approximately three times more common in males than in females, and the age of onset is predominantly the third decade—that is, after the vertebrae are fully formed—thereby differentiating it from osteomyelitis occurring in long bones. This age incidence is no doubt due partly to the fact that there is no true epiphyseal growth in the vertebral bodies, and partly to the presence of a cellular bone marrow with a sluggish blood flow, thereby encouraging embolism and thrombosis in pyæmic states. Such a condition of bone and blood flow is normally present in the metaphyseal areas of long bones, thus accounting for the more usual incidence of osteomyelitis in these bones in adolescence.

Aetiology and Pathology

The influence of trauma as an aetiological factor is doubtful, and in Kulowski's series of 102 cases there was a history of trauma in 30%. In the present series Case 4 appears to date from a fall, and Case 3 is of interest as occurring after a lumbar puncture, whether or not that was a factor; but in the remainder there does not appear to have been any injury.

The lumbar region is most frequently involved, and the bodies of the vertebrae are generally affected, usually as a metastatic phenomenon, the primary focus being recognizable in about half the cases as a topical infection such as a boil, whitlow, tooth infection, septic wound, or another focus of osteomyelitis; and the causative organism, if it can be obtained either directly or by blood culture or from the primary focus, is a *Staph. aureus*, less commonly *albus*, or rarely a streptococcus. Direct infection can of course occur.

Pyogenic infection in the early stages gives rise to an ulcerating lesion showing a liability to spread to adjacent segments.

This is due to the fact that the vertebral bodies lack a compact bony layer, thus allowing the intervertebral disk early to become subjected to the suppurative process; and the disk substance is rapidly and extensively destroyed by the action of the proteolytic enzymes of the pyogenic exudate and the adjacent body is directly infected. In tuberculous infection, however, the disk substance is not so readily destroyed, and, as it has no vascular or lymphatic connexion with the vertebral bodies bounding it, it offers a formidable barrier to the spread of the disease. For tuberculous infection to attack adjacent segments the process must spread under the anterior common ligament, whence it reaches neighbouring vertebrae by way of their anterior surfaces, and considerable remnants of disk substance may remain after destruction of adjacent segments by disease (Fig. 1).

FIG. 1.—Tuberculous disease of spine. Showing comparative persistence of intervertebral disk, collapse of the vertebra below and rarefaction of the bone of the anterior aspect of the vertebra above, and spread of disease anteriorly to, rather than through, the disk.

Radiologically these changes are of value in the differential diagnosis, as in pyogenic osteomyelitis early narrowing or disappearance of the intervertebral space is evident. Narrowing of the space is also seen in tuberculous disease, and in this case is due to disease-softened osseous or ligamentous tissue allowing the semifluid nucleus pulposus to prolapse into the vertebral bodies above and below, and is neither so early nor so marked a feature as in pyogenic infections. The abundant blood supply, with a local excess of calcium, results in early and massive new bone formation, giving rise at first to a "beaking" of the lower and upper margins of adjacent vertebral bodies, and later to a fusion of adjacent vertebrae by means of these bony outgrowths. Similarly the free blood supply and the cancellous nature of the bone rarely give rise to the formation of sequestra of such a size that they are not readily absorbed. This subperiosteal new bone formation, occurring often within a few months of the onset of the disease, is the exact antithesis of the pathology of tuberculosis of bone, where the essential lesion is destructive and where new bone formation and bony fusion hardly occur. In pyogenic osteomyelitis collapse of the bodies and gibbus formation are not common, as the severity of the symptoms leads to the patient's taking to his bed at an early stage of the disease. Suppuration is common and abscess formation often occurs, sometimes leading to the formation of large abscess cavities, which generally enlarge forwards and are guided in their course

usually by normal cleavage planes. Thus in the cervical region retropharyngeal abscesses may result; in the thoracic region posterior mediastinal abscesses, which may perforate pleural or pericardial cavities; in the lumbar region psoas or perinephric abscesses, and in the sacral region pelvic or pelvirectal abscesses, may be seen; and sinus formation is not an uncommon complication. Occasionally large abscesses form where the bone focus is minimal in extent and not detectable on x-ray examination. Unusually an epidural abscess occurs, and this results in compression, meningitis, or vascular disturbance in the cord, with a mortality rate of 50%. The onset of spinal symptoms in pyogenic osteomyelitis is sudden and dramatic compared with the slow and gradual appearance of similar symptoms in tuberculous disease, except in those rare cases in the latter condition where paraplegia has a sudden onset due to bone displacement. It is interesting to note that Browder and Meyers (1941) considered that 10 out of 14 cases of epidural abscess resulted as a direct spread from an osteomyelitis of the spine.

Signs and Symptoms

Clinically the onset is often acute, but sometimes subacute or insidious; in very acute cases the local signs may be overridden by the intensity of the toxæmia. Spontaneous intense lumbar pain, often diagnosed as lumbago or fibrositis, which is diffuse at first and later localized, is always present, and is usually of sufficient severity to confine the patient to bed, and often severe enough to render him helpless, fixed, and unable to move. It is accompanied by a marked degree of spasm of the erector spinae, and all movements of the spine are markedly limited and painful. Localized tenderness appears later owing to the original depth of the lesion, but once apparent it is very persistent. Should the disease attack the posterior processes, oedema and tenderness of the back muscles, and later abscess formation deep to or within these tissues, may occur. In the early stages a blood culture may be positive and the primary focus may be seen. Pyrexia and leucocytosis are present in varying degrees, but signs of an acute and severe systemic upset are often not prominent. An increasing leucocyte count indicates progress to abscess formation. When the bone focus is minimal an abscess may present clinically, and in cases of obscure, deep-seated pus pyogenic osteomyelitis of the spine should be considered. Where a sinus is present, injection of scrapings into a guinea-pig is of value in the differentiation of pyogenic from tuberculous osteomyelitis, or a secondarily infected tuberculous disease from an osteomyelitis of pyogenic origin. When the disease process is rapidly limited by the natural defences of the body—which, fortunately, is generally the case—the early tendency to a firm bony union is seen on x-ray examination, and may occur two to three months after the onset of the disease.

Diagnosis

The radiological findings are of great importance in the diagnosis of the condition, although in the fulminating cases no changes will be seen, as these have not had time to develop before a fatal outcome; and in some cases where the bone focus is minimal in extent they may never be evident (Case 1). When the disease attacks the body it may be two to three months before changes are seen on x-ray examination. The first sign is a narrowing of the intervertebral space, with a moth-eaten irregularity of the bodies bounding it. At the same time there is an increased density of the affected vertebrae, sometimes with areas of mottled rarefaction, in contrast to the generalized decalcification evident in early tuberculosis. At about the same time, or shortly afterwards, subperiosteal new bone is formed at the margins of contiguous vertebrae, leading to a beaking which continues to increase in size; these eventually fuse together, resulting in a bony ankylosis. This process is complete at a relatively early date, and in one case was seen seven months after the onset of symptoms in spite of incomplete immobilization in this particular instance.

The diagnosis in the early stages of the disease rests on the severe backache accompanied by pyrexia and a leucocytosis and possibly by rigors. In a number of cases there is a history of a primary focus of infection. Diagnosis is often not completely clear until a later stage, when x-ray changes become apparent. The differential diagnosis of the subacute or chronic

form from tuberculosis of the spine may present difficulties, but the following points should decide without any great doubt.

	Pyogenic Osteomyelitis	Tuberculous Osteomyelitis
Site of disease ..	Body usually, often appendages	Body almost invariably
Primary focus ..	Topical pyogenic infection present in 50%	Other tuberculous focus often detectable
Onset	Usually very sudden; sometimes gradual	Gradual
Pyrexia	Variable, often marked	Variable, seldom marked
Pain	Usually intense	Persistent aching
Leucocytosis ..	May be marked	Not a feature
Vertebral collapse	None	Usual
X-ray findings ..	Increased density. Subperiosteal new bone formation. Spread through intervertebral disk	Decreased density. No new bone formation. Spread via anterior surface of bodies
Cord involvement	Rare and acute onset	Common and gradual onset
Course	Short to bony fusion	Prolonged to recalcification and fibrous fusion

Treatment

The treatment of the condition consists in immobilization of the spine, preferably in a plaster bed, until the disease process is over and bony fusion is complete. Abscesses, if they form, should be evacuated with scrupulous attention to the prevention of secondary infection, and penicillin both locally and systemically plays an important part in the treatment. Fusion of the affected vertebrae by means of an Albee graft has been suggested, but this is not necessary, as new bone formation leading to bony ankylosis between adjacent diseased vertebrae is an early and constant feature.

Illustrative Cases

Case 1.—A child aged 4 was admitted with a history of being off colour for five days and complaining of a pain in his back. He showed signs of meningitis and there was intense spasm of the lumbar muscles. His C.S.F. contained pus and *Staph. aureus*. Laminectomy of the third and fourth lumbar vertebrae was done, and an abscess was found arising in the body of the third lumbar vertebra and perforating the dura. The arachnoid was intact. The abscess was evacuated; 30,000 units of penicillin were

instilled, and a further 60,000 units were injected into the ventricle. The patient made a complete recovery, but at no time were there any x-ray changes.

Case 2.—A man aged 54, on getting out of bed for the first time after treatment for multiple abscesses, experienced a sudden intense pain in the back. This pain confined him to bed, during which time

FIG. 3.—Skiagram of the same case 14 months after the onset of backache, showing firm bony union between beaks of affected vertebrae.

he showed a moderate fever with pyrexia up to 102° F. (38.9° C.). He was treated by recumbency, and three months later changes were apparent on x-ray examination (Fig. 2). Five months after the onset of symptoms subperiosteal new bone and beaking were seen, and he was allowed up in a plaster jacket. Bony fusion became apparent 14 months after the onset; this afterwards enlarged and strengthened (Fig. 3), and three months later he discarded all fixation and was symptomless, apart from stiffness of the lumbar spine.

Case 3.—A naval officer aged 32 developed pyaemic cellulitis of each arm following an osteomyelitis of the skull complicating a shrapnel wound. Sequestrectomy was done and the patient became symptomless. A lumbar puncture was performed to investigate the condition of the C.S.F. as a result of the head injury. Two months after this he developed a severe backache, with fever and a slight leucocytosis. He was treated in recumbency, and three months after the onset of backache x-ray examination showed signs of pyogenic osteomyelitis. The condition progressed satisfactorily and a sound bony ankylosis resulted (Fig. 4).

In this case a possible contributory factor is the lumbar puncture, causing a local lesion in the disk or adjacent bone, and leading to a focus of diminished resistance to infection. Alternatively the focus of disease and the lumbar puncture may have been coincidental.

Case 4.—A naval rating, aged 32, ten days after a fall down a pile of bombs developed an intense pain in the lumbar region of the spine. For the next three to four weeks he had a slight fever, the temperature rising to 102° F. (38.9° C.), with occasional rigors and a white cell count of 17,000. A month after the onset of this pain an upper premolar tooth was extracted, and pus containing a staphylococcus was obtained from the socket. He was treated in recumbency, and nine months from the onset firm bony fusion with a diminished disk space was seen on x-ray examination. He was returned to full duty six months later.

In this case it is reasonable to suppose that the fall caused vascular damage in the body of the third lumbar vertebrae,

FIG. 2.—Skiagram of Case 2 three months after the onset of backache, showing narrowing of the intervertebral space, moth-eaten irregularities of the bodies bounding the space, and generalized increased density.

setting up a local focus where staphylococci from the infected tooth socket lodged.

Case 5.—A naval rating aged 25 was admitted to hospital because of a sinus of the posterior chest wall following the incision of an abscess at this site eight months previously. A skiagram showed an increased density of the left side of the bodies of the third and fourth thoracic vertebrae, and the intervertebral space between these was narrowed. An oblique view showed beak formation of the

FIG. 4.—Lateral view in Case 3 seven months after the onset of backache, showing massive bony bridging.

lower border of the third dorsal vertebra. The adjacent heads and necks of the third and fourth ribs showed widening and irregular thickening, and a similar appearance was evident in the corresponding transverse processes. Examination of the pus from the sinus indicated a mixed staphylococcal and streptococcal infection, and biopsy of the sinus wall showed no evidence of tuberculous granulation tissue.

The records of this case are incomplete, but according to the patient he was feverish at the time of the dorsal backache. The x-ray appearances point to a pyogenic infection, although an original tuberculous infection with a secondary pyogenic one cannot be ruled out. It is in such a case that inoculation of a guinea-pig with sinus scrapings would be valuable, but this was not done owing to the patient's repatriation to Canada.

Summary

The aetiology, pathology, clinical signs and symptoms, and treatment of pyogenic osteomyelitis of the spine are described.

It is suggested that the disease is more common than has been thought.

It seems that many cases of osteomyelitis of the spine, labelled tuberculous, are in reality pyogenic in origin.

At least in adults the disease is less fatal than has been considered.

The notes of five cases are presented.

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TREATMENT OF OSTEOARTHRITIS BY LACTIC ACID INJECTION

A SERIES OF 26 CONSECUTIVE CASES IN GENERAL PRACTICE

BY

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Stimulated by the work of Grant Waugh on intra-articular injection of lactic acid with procaine into the hip we recently gave his treatment to a series of 26 patients. The series comprised 6 cases of arthritis of the hip, 18 of the knee, 2 of the wrist, and consisted of the following types: osteoarthritis of the elderly; post-traumatic; so-called "menopausal"; post-infective; and residual deformity stage of rheumatoid arthritis. The cases occurred in semirural general practice and were taken from all social strata in our valley community. Economic factors prevented serial radiographs and periodic estimation of the erythrocyte sedimentation rate, and the treatment was domiciliary in all instances but one.

Case records were kept as simple as possible, and notes of progress consisted of statements made by the patient and his relatives, together with my own observations. It was difficult always to assess evidence of progress or deterioration in objective terms except when the patient showed dramatically changed physical signs—e.g., doubled range of movement at the affected joint. A guide to progress in this disease is the distance that can be walked before and after treatment. This criterion was used in most cases. However, clinical medicine in general practice includes sundry observations of patients in the street, in shops, in the village dance hall, and in the public house. I should be more pleased to see an osteoarthritic at the end of a fish queue than a small change in her sedimentation rate. Grant Waugh's assessment of progress was based on the degree of overall disability, expressed as a percentage, taking 90 to 100% disabled to describe patients confined to bed, and 70 to 80% for those able to walk with considerable difficulty.

It is not easy to classify stages of recovery. So often psychological factors distort the clinical picture. It is well known that all forms of rheumatism and neurosis are often closely related, but it is not desirable here to add to the hothouse flavour of some of the observations made by certain workers in this field: "The cramped muscle reflects the cramped mind" is an illustration. Reference will be made subsequently to certain features of anxiety which obscure the slighter signs of recovery in this type of patient.

The clinical state before and after treatment was based on inquiry into the following: pain and tenderness; deformity and posture; anorexia and insomnia; maximum walking distance; stiffness and alteration of gait; effusion; mental distress.

Below are given a table showing results of treatment in the series of 26 and records of four typical cases.

Joints Affected	No. of Cases		Age Range	Av. No. of Injections	Results		
	M.	F.			Better	No Change	Worse
Hips ..	4	2	36-67	4	5	1	0
Knees ..	1	17	42-73	4	17	1	0
Wrists ..	0	2	—	2	1	1	0

Case Histories

Case 1.—Mr. D., a landworker aged 36, had suffered from osteoarthritis of the left hip for 7 years, the result of a fractured femoral neck in 1927 (4 months in plaster). His symptoms were pain, stiffness, and insomnia. Examination revealed quadriceps and gluteal wasting, concealed hip flexion, flexion 60°, extension *nil*, adduction and abduction very small, rotation *nil*. All movements were painful. Walking distance before treatment: 1/4 mile (400 metres) in great pain. He was on the point of giving up his employment. Treatment consisted of four injections. The first injection brought a dramatic improvement; the patient could not only walk easily, but was actually able to run—something he had not been able to attempt for several years. The third and fourth injections produced much pain, and work stopped for 10 weeks. He is now back at work, and can walk up to 4 to 5 miles (6.5 to 8 km.) a day. There is still pain in the joint, but he can tie his left shoe-lace. All movements have increased, particularly flexion—almost to 90°. There is no concealed hip flexion. A radiograph