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# DISCOSPONDYLITIS AND ARTHRITIS IN SWINE ERYSIPELAS

By

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Erysipelas is one of the more common bacterial diseases of pigs. It is caused by Erysipelothrix insidiosa (previously rhusiopathiae), an organism described in 1882 by *Pasteur and Dumas* and demonstrated to be the cause of the disease by *Löffler* in 1886. The acute septicaemic form of erysipelas, apart from its typical exanthema, clinically and pathologically resembles other septicaemic diseases. If an animal survives an acute phase, a chronic form of erysipelas can develop with lesions in the endocardium and joints. Sometimes these chronic lesions appear without having apparently been preceded by an acute phase.

Erysipelas arthritis has enjoyed increasing interest during the last few decades (*Ward* 1922, *Buitenhuis* 1935, *Wernery* 1937, *Grashuis* 1939, *Collins and Coldie* 1940, *Doyle* 1951, *Usdin, Ferguson and Birkeland* 1952, *Hughes* 1955, *Sikes, Neher and Doyle* 1955, 1956, 1957, *Sikes* 1958, 1959, *Neher, Swenson, Doyle and Sikes* 1958, and *Dietz and Kuntze* 1959). The arthritis associated with E. insidiosa differs in many respects from the arthritis caused by pyogenic bacteria. Pyogenic bacteria cause the filling of the joints with copious amounts of pus and often extensive destruction of bony tissue as well. The erysipelas joint, on the other hand, is characterised by strong proliferative changes. It has often been claimed that in erysipelas arthritis of prolonged duration no bacteria can be demonstrated. *Sikes et al.* (1955), for example, could not recover the organism from arthritic joints for longer than 226 days after infection.

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One reason why erysipelas arthritis has attracted so much attention is its morphological resemblance to rheumatoid arthritis in human beings (*Doyle* 1951, *Sikes, Neher and Doyle* 1955, 1956, 1957, *Sikes* 1958, 1959). There are even other aspects which are of comparative pathological interest. Sensitisation resulting from vaccination has been associated with the occurrence of arthritis (*Neher, Swenson, Doyle and Sikes* 1958) and joint changes in their turn have been associated with changes in the kidneys and adrenals (*Sikes, Neher and Doyle* 1957).

During recent years röntgen techniques have been increasingly utilised for the clinical diagnosis of joint diseases in pigs. We have noticed that many of the lesions which had previously been interpreted as dietetic osteoarthropathies resembled those described by *Sikes et al.* (1955, 1956) and *Jansen et al.* (1956) in naturally-occurring or experimentally-induced erysipelas arthritis. In addition to these joint lesions we have also noticed changes in the vertebral column. Spondylitis (*Turner* 1949, *Doyle* 1958) and spondylarthritis (*Buitenhuis* 1935, *Sikes et al.* 1955) in erysipelas have been mentioned only in passing in text books and original articles and as far as we can see, have not been thoroughly studied. When we extended our observations to slaughter pigs we found also here that lesions in the intervertebral space very often occurred in pigs with erysipelas arthritis. Here we use the term intervertebral space to refer to the discs, the cartilaginous end-plates, and the epiphyses of the vertebral bodies. Apart from their intrinsic interest, these vertebral lesions can perhaps throw some light on the pathogenesis of a disease which is important for both pig husbandry and food hygiene. There are also aspects of interest for comparative disc pathology. In human beings disc lesions caused by infectious agents are primarily a paediatric problem and seem to have features in common with the lesions in pigs.

## MATERIAL AND METHODS

Twelve pigs with chronic erysipelas arthritis were available for clinical, röntgenological, pathological, and bacteriological study. Another 32 examples were obtained from the autopsy material of the State Veterinary Medical Institute and from the Stockholm slaughter house[1]). The ages of the pigs ranged from

[1]) The kind cooperation of Dr. *T. Petrelius* is gratefully acknowledged.

three to seven months. Conventional methods were used. After the pigs were killed or died the vertebral column was split sagitally by sawing and one half used for bacteriological studies and the other half examined for the presence of lesions. Material for histological examination was removed so that the intervertebral disc formed the centre of the section. After fixation in ten per cent formalin osseous tissues were decalcified in five per cent nitric acid; the usual haematoxylin-eosin and van Gieson stains were used. In addition to affected joints and intervertebral discs, other organs were examined bacteriologically as the opportunity arose. Since the material available for pathological examination was not uniform — sometimes the whole body, sometimes only selected organs and tissues — it was impossible to follow a uniform plan in taking bacteriological specimens.

## CLINICAL OBSERVATIONS

The animals available for clinical examination originated from fattening establishments to which they had come at two months of age. At the time of purchase or shortly afterwards locomotory difficulties had been noticed. Growth was poor. According to the various owners no acute erysipelas had occurred and no vaccination against erysipelas had been practised.

The pigs preferred to remain lying and could rise only with difficulty. When standing, they supported themselves on the tips of the digits and kept the phalanges practically upright, flexed the carpi and brought the points of the hocks together. They moved with a stilted yet dainty gait. Bilateral exostoses could be palpated distal to the tarsus and in a few pigs on the carpus as well. Fluid accumulation could not be detected in any joint. The back was arched.

The only abnormalities noted in blood samples were relative lymphocytosis in two pigs (66 and 86 per cent respectively) and an increase in ESR to 26, 27, 32, and 99 mm/60 min. for four pigs.

The pigs were kept under observation for periods varying between two and sixteen weeks. Only two showed any clinical improvement during this period and both these animals had been given 5,000—10,000 I.U. penicillin and 10—20 mg. streptomycin per kg. body weight. These pigs gained an average of 4 kg. per week and mowed about more freely; the abnormal position of the joints and the palpable changes remained unaltered. Of the

other animals four were treated with fish liver oil and phosphate in various forms with no other effect than a slight improvement in growth. The untreated pigs gained about 2 kg. per week each.

## RÖNTGENOLOGICAL OBSERVATIONS

The various röntgenological examinations made on the twelve pigs described above are listed in Table 1.

*Carpal changes* were noted in four animals and were bilateral in three. The changes seemed to affect primarily the carpal-metacarpal joint. Large exostoses were present about the edges of the articular surfaces and in some instances there was distinct destruction of the carpal bones in the distal row. In more severely affected joints the changes involved the proximal carpal bones as well.

In the *hock joints* of all animals there were changes in the intertarsal and the tarso-metatarsal articulations, the arthrodia. Bilateral changes were noted in seven animals. The distal tarsal bones had become flatter and broader and bulged dorsally. The arthrodia were deformed and partly obliterated. Large articular and periarticular exostoses dominated the röntgen appearance, especially towards the dorsal surface. In severely affected hocks the lesions also involved the tibio-tarsal articulation, often with a thinning out of the bone structures or cyst formation in the hock bones and particularly of os tarsi tibiale.

Lesions were identified in the *vertebral column* of nine pigs. The distribution of the lesions is described in connection with the pathological description. Changes were limited to the discs and their immediate surroundings. First the discs became narrower, then changes in the epiphyses of the vertebral bodies appeared. Here these were manifest as spotty osteoporosis surrounded by sclerosis or as more extensive osteoporosis involving the epiphyses abutting upon both surfaces of a disc. In places in what were presumably older lesions, there were large ventral syndesmophytes. The most severe changes seen were fusion of the vertebral bodies right through the intervening disc so that this structure was partly or even wholly obliterated.

As for *the rest of the skeleton,* it seems that most of the joints can be affected but that the lesions are not evident on the röntgenograms before they become severe. What becomes apparent then are mainly osteolytic processes close to the joints but remarkably little new formation of bone. As can be seen from

the table, changes were observed in the scapular joints as often as in the carpi. The femoro-tibial joints and the pastern and digital joints never showed any changes.

## PATHOLOGICAL AND BACTERIOLOGICAL OBSERVATIONS

Of the 44 pigs with polyarthritis included in this study, 27 had *changes in the intervertebral spaces*. The changes involved

| | | | | |
|---|---|---|---|---|
| 1 | intervertebral | space | in 3 | animals |
| 2 | intervertebral | spaces | „ 5 | „ |
| 3 | „ | „ | „ 6 | „ |
| 4 | „ | „ | „ 3 | „ |
| 5—22 | „ | „ | „ 10 | „ |

The distribution of the affected discs in the various parts of the vertebral column is shown in Fig. 1. Our material gives no reason to suppose that the changes were particularly prevalent in any region.

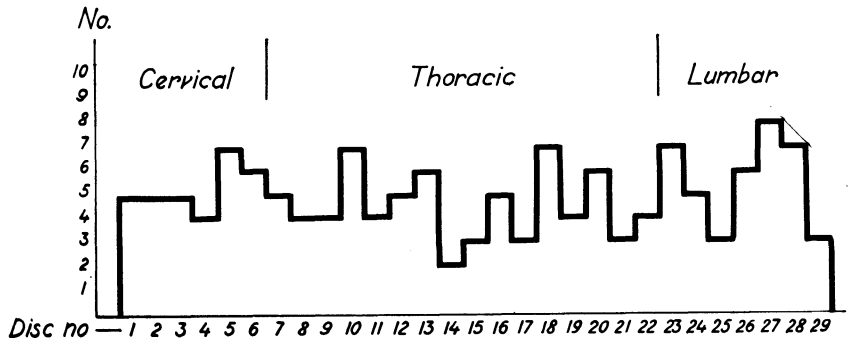


Fig. 1. Distribution of discospondylitis within the vertebral column (143 intervertebral spaces affected in 24 pigs from which the entire vertebral column was examined).

As was mentioned previously, changes were seen in the intervertebral spaces, a convenient phrase used here to cover the discs, the cartilaginous end-plates, and the epiphyses of the vertebral bodies. The diaphyses, on the other hand, were involved only incidentally and slightly when the lesions in the intervertebral space were particularly severe. In the *initial phase,* macroscopical changes may be not much more than a reddish discolouration of the nucleus pulposus and usually of the inner portion of the annulus, the cartilage plate, and the epiphyseal bone as well. The nucleus maintains its normal gelatinous consistency. In the *next*

*phase* all the structures of the intervertebral space are regularly involved and the disc has a central cavity filled with necrotic and haemorrhagic disc and epiphyseal tissue or with grey-red granulation tissue. In the fully developed *chronic phase* the disc has become much narrower after disappearance of the necrotic tissue and its replacement by a steadily contracting, greyish granulation tissue. In a sagittal section the disc is represented by a strongly waved connective tissue band and from this band extend branches of connective tissue into the epiphyses to the extent that these were involved in the process. This phase is often accompanied by sclerosis of adjacent bony tissue, and by osteophyte formation, particularly ventrally but occasionally even dorsally, and finally by ankylosis through this osteophyte formation and through fusion of exposed bony surfaces of adjacent vertebral bodies. In one pig formation of bony tissue dorsally slightly compressed the spinal cord.

*Changes in the joints of the extremities* were distributed as shown in Tables 1 and 2. Only relatively severe changes are recorded in these tables. In most pigs, however, several joints were affected as could be seen from the hyperaemia and villous hypertrophy of the synovial membrane, the increase in the amount of synovial fluid which sometimes contained blood and was opaque, and the thinning of the joint cartilage, sometimes to the point of obvious erosion. In those animals in which the intervertebral joints were examined, similar lesions were generally seen at this site. The full-blown arthritic lesions appear in one of two main variants involving joints with large cavities, such as the stifle joints, or joints of the arthrodia type such as the carpus and tarsus. The first of these variants is characterised by large amounts of serofibrinous or fibrinopurulent exudate, a pronounced and often polyp-like proliferation of the synovial membrane, extensive erosions of the cartilage and in association with these, destruction of the subchondral bone, the filling out of the erosions with granulation tissue, and osteophyte formation about the edges of a joint. Bursae and tendon sheaths in the vicinity may also be filled with exudate of the same type as in the joints and also display obvious hypertrophy of their synovial linings.

The other type of arthritis, seen in the arthrodia of the tarsus for example, is distinguished mainly by its dryness. Destructive processes clearly dominate and are followed by a strong osteo-

*Table 1.* Pathological and bacteriological findings in clinical cases of arthritis in pigs.

| Pig no. | No. of affected intervertebral spaces | | | Joints affected | | | | | | Bacteriological findings | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cervical spine | Thoracic spine | Lumbar spine | Hip | Knee | Hock | Shoulder | Elbow | Carpus | Intervert. spaces | Joints | Other organs | Remarks |
| 531 | (2) | (9) | (4) | (+) | + | (+) | (+) | (+) | (+) | + | + | spleen, lymph node — | Erysipelothrix insidiosa (S- and R-form) |
| 532 | 1 | (0) | (0) | (—) | (—) | (+) | (—) | (—) | (—) | ÷ | ÷ | ÷ | |
| 1607 | (1) | (2) | (2) | + | + | (+) | (+) | + | + | + | + | spleen, kidney, lymph node — | E. insidiosa |
| 1608 | (0) | (1) | (2) | + | + | (+) | (+) | + | (+) | — | + | spleen, lymph node — | E. insidiosa |
| 1627 | (5) | (10) | (7) | (—) | (—) | (+) | (—) | (—) | (—) | — | — | spleen, lymph node — | |
| 1628 | (0) | (3) | (2) | + | + | (+) | (+) | + | (+) | ÷ | + | spleen, lymph node — | E. insidiosa |
| 123 | (0) | (3) | (0) | (—) | (—) | (+) | (—) | (—) | (—) | — | — | ÷ | |
| 124 | (0) | (0) | (0) | (—) | (—) | (+) | (—) | (—) | (—) | ÷ | — | lymph node — | |
| 8062 | (1) | (0) | (2) | (—) | (—) | (+) | (—) | + | (—) | — | + | kidney, spleen, heart valve, lymph node — | Strept. viridans Aggl. titer against E. i. 1:1280 |
| 5900 | ÷ | ÷ | (0) | (—) | (—) | (+) | —[1] | —[1] | —[1] | — | + | ÷ | E. insidiosa |
| 8896 | 0 | 2 | 1 | —[1] | (—) | (+) | (—) | (—) | (—) | — | + | blood, lymph node, heart valve, kidney, spleen — | Strept. Aggl. titer against E. i. 1:160 |
| 9015 | (0) | (0) | (0) | (—) | (—) | (+) | + | + | + | ÷ | — | bile, blood, lymph node, heart valve, kidney, spleen — | Aggl. titer against E. i. 1:320 |

÷ = not examined — = negative finding Parenthesed symbols mean agreement between
+ = positive finding [1] = not examined röntgenologically röntgenological and pathological findings.

*Table 2.* Pathological and bacteriological findings in 32 autopsied pigs with arthritis.

| Pig no. | No. of affected intervertebral spaces | | | Joints affected | | | | | | Bacteriological findings | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cervical spine | Thoracic spine | Lumbar spine | Hip | Knee | Hock | Shoulder | Elbow | Carpus | Intervert. spaces | Joints | Other organs | Remarks |
| 461 | 0 | 0 | 0 | — | — | — | — | — | + | ÷ | ÷ | lymph node — | Coryneb. pyogenes |
| 462 | 0 | 0 | 0 | — | + | — | — | — | — | ÷ | — | lymph node — | |
| 465 | 0 | 0 | 0 | — | + | — | — | — | — | ÷ | ÷ | lymph node — | |
| 467 | 0 | 0 | 0 | — | + | — | — | — | — | ÷ | + | lymph node — | E. insidiosa |
| 471 | 0 | 0 | 0 | — | + | — | — | — | — | ÷ | — | lymph node — | |
| 473 | 0 | 0 | 0 | — | + | — | — | — | — | ÷ | — | lymph node — | |
| 468 | 0 | 0 | 0 | — | + | + | — | — | — | ÷ | — | lymph node — | |
| 482 | 0 | 0 | 2 | — | + | — | — | — | — | + | — | lymph node — | E. insidiosa |
| 2579 | 0 | 0 | 0 | — | — | + | — | + | — | — | — | lymph node — | |
| 2450 | 6 | 7 | 9 | + | + | + | + | + | + | + | + | ÷ | E. insidiosa |
| 2298 | 0 | 1 | 1 | — | + | + | — | + | + | + | + | lymph node — | E. insidiosa |
| 2127 | 0 | 0 | 1 | — | + | + | — | — | — | — | + | ÷ | E. insidiosa |
| 1918 | 1 | 8 | 1 | — | + | + | — | + | + | + | + | ÷ | E. insidiosa |
| 1442 | 0 | 0 | 0 | + | + | + | — | + | + | — | — | ÷ | |
| 284 | 0 | 2 | 3 | — | + | — | — | — | — | — | + | lymph node — | Coryneb. pyogenes |
| 2776 | 0 | 0 | 4 | — | — | — | — | + | — | + | + | heart valve +, lymph node —, kidney + | E. insidiosa |
| 4056 | ÷ | ÷ | 2 | + | ÷ | ÷ | ÷ | ÷ | ÷ | — | ÷ | ÷ | |
| 3059 | 1 | 1 | 0 | — | + | + | — | + | — | + | + | ÷ | E. insidiosa |

÷ = not examined
\+ = positive finding
— = negative finding

*Table 2* (continued).

| Pig no. | No. of affected intervertebral spaces | | | Joints affected | | | | | | Bacteriological findings | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cervical spine | Thoracic spine | Lumbar spine | Hip | Knee | Hock | Shoulder | Elbow | Carpus | Intervert. spaces | Joints | Other organs | | |
| 2530 | 4 | 3 | 4 | Slight to moderate generalized arthritis | | | | | | — | — | heart valve | + | Strept. β-hemolytic |
| 1408 | 1 | 0 | 3 | | | | „ | | | + | + | | ÷ | E. insidiosa (S- and R-form) |
| 1407 | 0 | 0 | 0 | | | | „ | | | — | + | | ÷ | E. insidiosa |
| 988 | 3 | 2 | 1 | | | | „ | | | + | + | | ÷ | E. insidiosa (S- and R-form) |
| 528 | 2 | 0 | 1 | | | | „ | | | + | + | lymph node | + | E. insidiosa |
| 431 | 1 | 0 | 0 | | | | „ | | | + | + | kidney, heart valve | — | E. insidiosa |
| 7004 | 1 | 0 | 2 | | | | „ | | | ÷ | — | heart valve, spleen, lung, tonsil<br>kidney | —<br>+ | E. insidiosa |
| 257 | 0 | 2 | 0 | | | | „ | | | + | ÷ | | ÷ | E. insidiosa |
| 722 | 3 | 0 | 1 | | | | „ | | | ÷ | — | | ÷ | |
| 517 | 0 | 0 | 0 | | | | „ | | | ÷ | — | heart valve<br>liver, spleen, lymph node | +,<br>—<br>— | E. insidiosa |
| 721 | 0 | 0 | 0 | | | | „ | | | ÷ | — | | ÷ | |
| 1658 | 0 | 0 | 0 | | | | „ | | | — | — | | ÷ | |
| 2777 | 0 | 0 | 0 | | | | „ | | | — | + | heart valve, lymph node | — | E. insidiosa |
| 2778 | 0 | 5 | 2 | | | | „ | | | + | — | heart valve, lymph node | — | E. insidiosa |

÷ = not examined
\+ = positive finding
— = negative finding

phytotic reaction and even fusion between the joint surfaces. A longitudinal section through such a tarsus often reveals signs of different phases beginning with a reddish discolouration of the articular cartilage, especially between the distal tarsal bones, then destruction of the cartilage and involvement of the bone, usually as a reddish lesion about 5 mm. in diameter in the centre of the articular surface (to give an appearance closely resembling the lesions in the intervertebral discs), and continuing with osteophyte formation about the margins and finally fusion with complete obliteration of the joint space.

The *other autopsy findings* will not be gone into here. It can be mentioned, however, that the body lymph nodes and the spleen are usually hyperplastic. Fibrinous valvular endocarditis has been observed in a few animals. One usually encounters, however, either endocarditis or joint and vertebral lesions in any particular animal with chronic erysipelas.

Upon *microscopical examination* of the spinal lesions early changes seemed to be limited to the nucleus pulposus. In such instances there was granular degeneration of the nuclear tissue, an abundance of erythrocytes and leukocytes and some macrophages of which a few contained haemosiderin. Often, however, fragments of cartilage and connective tissue were observed as a sign that the process also involved other structures of the intervertebral space even if this was not apparent in the plane of histological section. Small foci of osteomyelitis in the epiphyses, and sometimes even enclosed islands of nuclear tissue, were commonly observed in sections from this phase. In other instances, osteomyelitis could be detected in the epiphyses, especially close to the epiphyseal lines, without concomitant disc changes. After examining a large series of these lesions it seems obvious that wherever the changes may have been initiated, they very rapidly involve both the disc and the epiphyses of the adjacent vertebral bodies. When once established, destruction of the disc, the cartilage plate and the epiphyses increases and at the same time there is a strong tendency for proliferation of cartilage and connective tissue from the cartilage plate and from the epiphyseal line. It is possible to see large defects of the cartilage plate filled with proliferating cartilage and connective tissue to unite the original epiphyseal line with the disc remnants. A similar histological appearance can be found in the joints of the extremities when destruction of the articular cartilage leads to subchondral

cysts containing necrotic bone marrow, bone fragments and, usually, a fibrinopurulent exudate, and later, to a filling-out with connective tissue and cartilage. In the joints there is also the characteristic proliferation of the synovial membrane which may attain a polyp-like appearance with an abundance of lymphocytes and plasma cells in the propria and a covering of endothelial cells in several layers.

The *bacteriological findings* are also included in the tables. Isolations were obtained from 28 animals. Apart from two isolations each of streptococci and Corynebacterium pyogenes, Erysipelothrix insidiosa was recovered from the animals. The E. insidiosa strains proved to be sensitive to trypoflavine even in concentrations of 0.002 per cent. This observation means that infection with the avirulent vaccine manufactured by this Institute was not responsible (*Wiidik* 1959). There is, of course, the reservation that the organisms have not altered their biochemical characteristics in vivo. From one pig (O.531/60) the R-form was isolated from the vertebral lesions and the S-form from the joints of the extremities. In two pigs R- and S-forms were obtained from different joints.

*Pathogenicity tests* of the two strains from O.531/60 revealed a difference between them. The R-form, even in dilutions of 1:100,000, killed mice within a few days but the S-form isolated from the joints, even when 1—3 ml. of a 20-hours-old broth culture were given intraperitoneally, did not kill mice. Since it is conceivable that the R-threads in the body under favourable conditions can disintigrate into smaller particles and since the R-colonies on agar plates are larger than S-colonies, neither the number of colonies nor the amount of infective substance are quantitatively comparable. Both variants from O.561/60 were also injected i.p. into mice in non-lethal doses as shown below.

17 mice with 0.5 ml. $10^{-1}$ of the S-form

15 mice with 0.5 ml. $10^{-7}$ of the R-form.

These mice were killed after 7 weeks and the joints of the extremities and the vertebral column were examined histologically. No changes in the discs were observed but arthritis was common, particularly in the stifle joints and occasionally in the intervertebral joints as well.

## DISCUSSION

We commenced by mentioning the renewed interest in erysipelas arthritis because of points of similarity in morphology with rheumatic arthritis of human beings. This aspect is not our major concern here. What we are going to discuss are the clinical significance of erysipelas arthritis, some views on the pathogenesis of chronic erysipelas and in particular, the significance of the spinal lesions.

*Erysipelas arthritis.*

The studies described here were initiated by the observation that clinical signs referable to the joints in pigs two months of age and older and which have generally been considered to represent a dietetic osteoarthropathy could instead have a bacterial origin, usually chronic erysipelas. Erysipelas is one of the commoner bacterial diseases of pigs. *Grätz* (1960), for example, found an incidence of nearly five per cent among normal slaughter pigs. E. insidiosa has been isolated from the tonsils of 67 per cent of clinically healthy animals (*Goerttler and Hubrig* 1960). Although streptococci can result in disease identical with that produced by E. insidiosa, erysipelas is the disease which warrants practical attention. According to some reports (*Grey et al.* 1941, *Wellman* 1954, and *Petri and Schurian* 1959) E. insidiosa can be isolated from 70 to 80 per cent of arthritic joints in pigs. The assumption that the greater part of the remainder are also examples of erysipelas in spite of the negative bacteriological results is supported by the observations on experimental erysipelas in which no bacteria could be recovered from some advanced lesions (*Sikes et al.* 1955). In our material the organism was demonstrated in 65 per cent of the joints examined.

Non-infectious joint lesions in pigs are often described in text-books as rachitis or osteomalacia. The presence of authentic rachitis is doubtful in many of these instances. In our experience rachitis seldom occurs in pigs. On the whole it seems that possible dietetic backgrounds to osteoarthropathies in pigs have been insufficiently studied. *Hupbauer's* (1936) hypothesis of mineral deficiencies giving a predisposition for erysipelas arthritis needs further investigation. The same can be said of many other osteoarthropathies in pigs including those described by *Christensen* (1954) and *Sabec* (1960) as a cause of impotentia coeundi in boars. Our material includes a 3½-year-old boar slaughtered

because of impotentia coeundi (No. 4056, Table 2). From this observation it appears that erysipelas arthritis and discospondylitis must be considered as a possible factor in these regards.

*Pathogenesis of chronic erysipelas.*

Variations in the clinical and morphological appearance of erysipelas seem to a great extent to be a function of variations in virulence of different strains of the organism. From septicaemic erysipelas, for example, one generally isolates highly virulent E. insidiosa while erysipelas arthritis yields poorly virulent strains (*Wellman* 1954). It is unknown whether the strains which give arthritis are the poorly virulent strains which normally vegetate in the body of the animal and its surroundings or whether these strains have aquired this property through dissociation in vivo. As has been reported by others (*Wernery* 1937, *Bakos and Dinter* 1948) we have recovered both S- and R-variants from a single animal. The mere observation gives no indication whether or not dissociation has occurred in vivo. In connection with some Salmonella infections, however, we (*Thal and Holmqvist* 1957) have found evidence suggesting that dissociation can occur in various organs to give less virulent variants.

The virulence of R-forms has generally been considered to be less than that of the S-forms. *Bakos and Dinter* (1948) found for four strains that the R-variant could be as virulent, less virulent, or avirulent in comparison with the S-variant. It is, then, remarkable that the R-variant from one of our pigs (O.531/60) was so much more virulent than the S-variant.

The phenomenon of dissociation in the pathogenesis of chronic erysipelas as well as immunopathological aspects seem to be worth further study.

*The spinal lesions.*

Changes in the intervertebral space in chronic erysipelas have hitherto attracted but little attention. These changes were present in about two-thirds of pigs with arthritis. Destructive, inflammatory, and proliferative processes involve the three main structures of the intervertebral space — the disc, the cartilage plate, and the epiphysis of the vertebral body. The localisation of the lesions resembles that of Brucella spondylitis. Brucella spondylitis, according to *Lowbeer* (1959), is characterised by destructive caseous foci which develop through coagulative necrosis and the secon-

dary deposition of calcium salts. Brucella suis infection does not now occur in this country and this organism could not be demonstrated in our material.

That the erysipelas lesions in the vertebral bodies were so definitely limited to the intervertebral region and in no instance produced osteomyelitis in the diaphyses may reflect local circumstances such as nutrition. At the early age when infection occurs the intervertebral space is highly vascular. Even the annuli fibrosi contain blood vessels at this age before attaining the avascular adult state. Infectious lesions of the discs, therefore, cannot occur in the adult unless osteomyelitis in the vertebral bodies extends directly into them. Conditions are otherwise in young individuals and there are many clinical reports of infectious discospondylitis in children. The erysipelas discospondylitis in young pigs can have comparative interest. Apart from questions of local nutrition, the fact that the epiphyses are growth centres may also influence the localisation of the lesion, especially if — as has been suggested (*Hupbauer* 1936) — a mineral deficiency and disturbance in bone formation is also present.

In human beings as in animals, spinal osteomyelitis has been observed in the course of various infections. In some of these diseases — tuberculosis, brucellosis, and various pyaemias — the spinal lesions are characteristic features. The lesions are generally limited to the vertebral bodies, sometimes with extension to the adjacent discs. These infections have been serious and the mortality great. Now that tuberculosis and brucellosis are steadily being eliminated from many countries and antibiotics successfully check the pyogenic bacteria, spinal osteomyelitis has largely lost its significance.

Since *Smith*'s (1933) report of a spinal disease with a mild course and mainly manifest by a narrowing of the intervertebral space, a few descriptions of this disease have appeared. We consider — on grounds to be discussed later — that the term "discospondylitis" as used in French writings (*Vignon et al.* 1956, *Verhaeghe* 1958) is morphologically adequate. Discospondylitis has been described in children (*Saenger* 1950, *Bremner and Neligan* 1953, *Mathews et al.* 1957, *Gandolfi* 1959, and *Doyle* 1960) and in material mainly obtained from children (*Harbin and Epton* 1933, *Smith* 1933, and *Ghormley et al.* 1940).

Knowledge of discospondylitis in human beings is based almost exclusively on clinical observations. *Doyle* (1960) has

proposed that the lesion be considered as a separate entity. He considers that discospondylitis differs from spinal osteomyelitis through its definite location in the intervertebral space and its infrequent and minimum vertebral involvement. As for pathogenesis he proposes that trauma to the spine in the presence of transient bacteriaemia may have its place. *Mathews et al.* (1957) and *Saenger* (1950) share his opinion. *Bremner and Neligan* (1953) suspect that staphylococci may be responsible. *Ghormley et al.* (1940) noticed that more than half their patients had recently gone through infections of various types. *Ford and Key* (1955) and *Cameron and Holmes* (1955) have described infections of the disc space with pyogenic bacteria in conjunction with disc operations or shot wounds in the back; these examples demonstrate that a low-grade infection can develop in the disc space and be confined there to produce discospondylitis.

Discospondylitis in human beings, like the spinal changes of erysipelas in pigs, are characterised by narrowing of the intervertebral space. Destructive processes, sometimes surrounded by sclerosis, also develop in the epiphyses of the vertebral bodies. In advanced lesions osteophytosis and fusion of the vertebral bodies appear. These lesions are identical with those seen in connection with erysipelas in pigs. Erysipelas elicites an inflammatory process which, in practically every instance, involves all the structures of the disc space (disc, cartilage plate, epiphysis of the vertebral body). The term "discospondylitis" can be justified morphologically.

As for pathogenesis, we have been unable to determine whether the process begins in the disc or in the adjacent bony tissue. Actually, it may be reasonable to assume that both sites are equally potential. In any event, the process rapidly extends to result in disappearance of the disc, destruction of bony tissue, and a tendency to fusion of the vertebral bodies. *Sullivan and McCaslin* (1960) have shown through experiments on dogs that this development depends upon prolonged proteolytic activity. Fusion of the vertebral bodies invariably resulted when they injected living Staphylococcus aureus into the discs. The proteolytic activity was presumed to be initiated by the activity of bacterial enzymes (kinases) in converting blood plasma plasminogen to plasmin. Some examples of discospondylitis in pigs were caused by streptococci which through streptokinase could parti-

cipate in such a reaction. The enzymatic set-up of E. insidiosa has not yet been investigated in that respect.

The discospondylitis of erysipelas would seem to offer a suitable model for studies of dietetic, infectious, and immunopathological factors in the development of deforming joint diseases.

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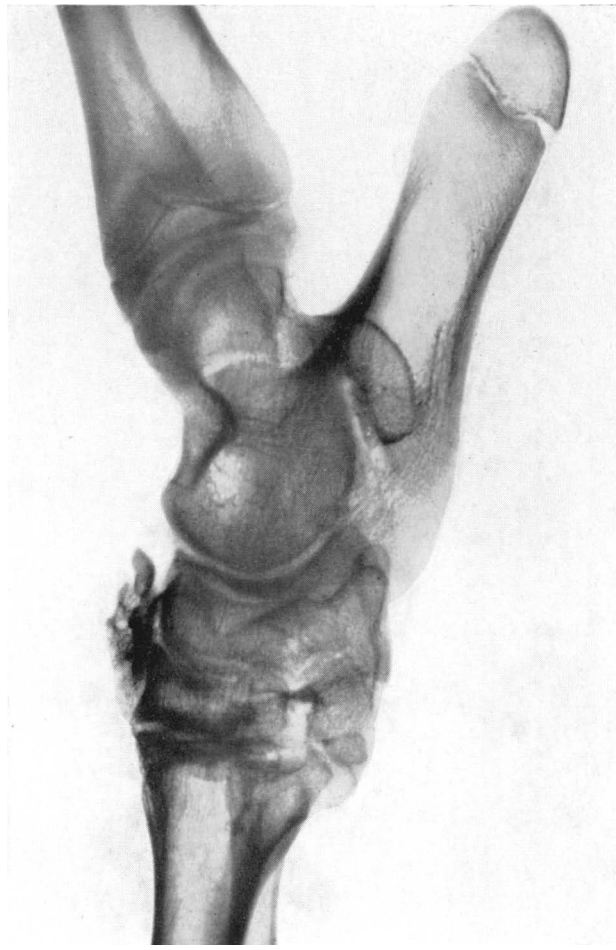
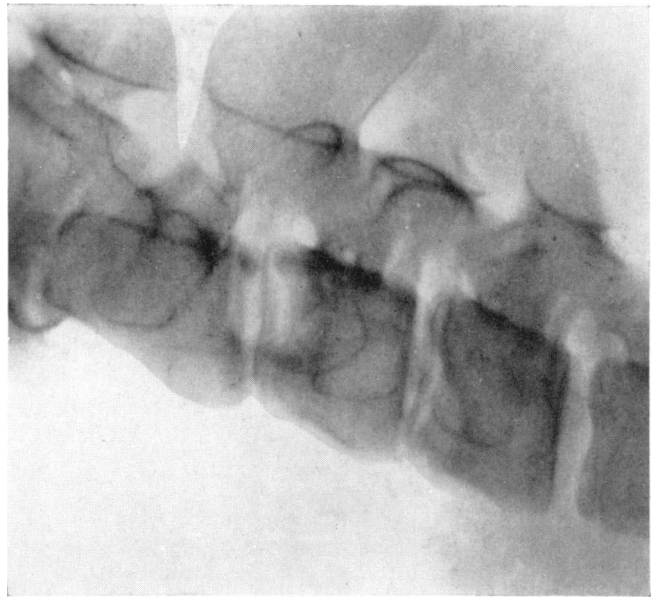
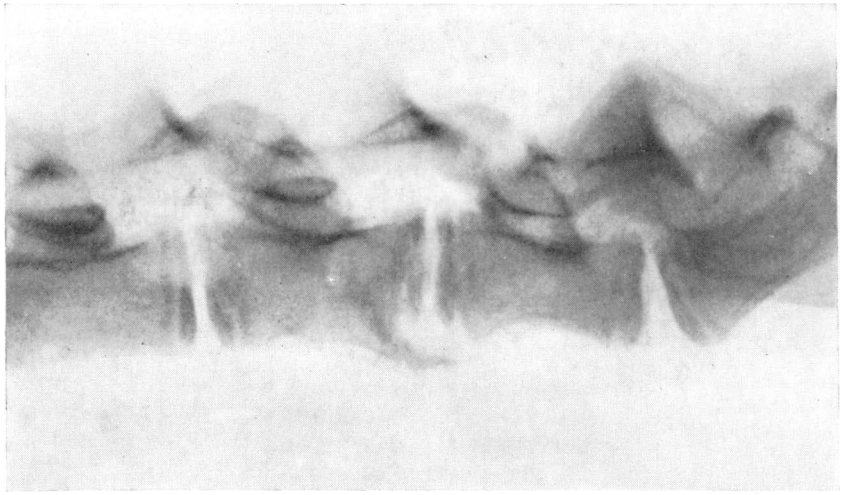


F i g. 2. Pig O. 1608/59, röntgenogram of hock joint. Typical changes of partial obliteration of the arthrodia and periarticular exostoses, particularly on the plantar surface.



F i g. 3. Pig O. 531/59, röntgenogram of neck from $C_2$ to $C_5$. Osteolysis in the $C_2$ and $C_3$ vertebral bodies with the disc in the centre. This disc and the disc between $C_3$—$C_4$ are narrower than normal. Destructive lesion in the cranial portion of the $C_4$ vertebral body.



F i g. 4. Pig O. 1627/59, röntgenogram of the caudal portion of the lumbar region, $L_4$ to $S_1$. Osteosclerosis in the vertebral bodies of $L_6$ and $L_7$ where they abut upon the disc. Increased density in the disc. A large ventral exostosis surrounds a destructive lesion.

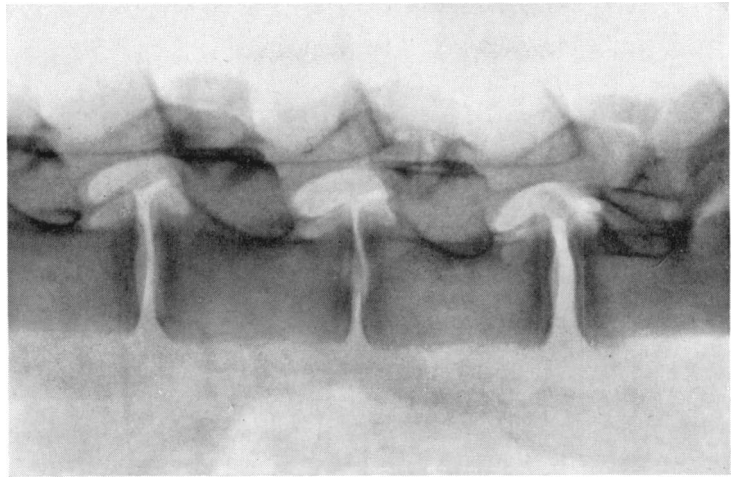


Fig. 5. Pig O. 531/59, röntgenogram of lumbar region, $L_4$ to $L_7$. The disc between $L_5$ and $L_6$ is narrower than the neighbouring discs. Signs of early changes in this disc.

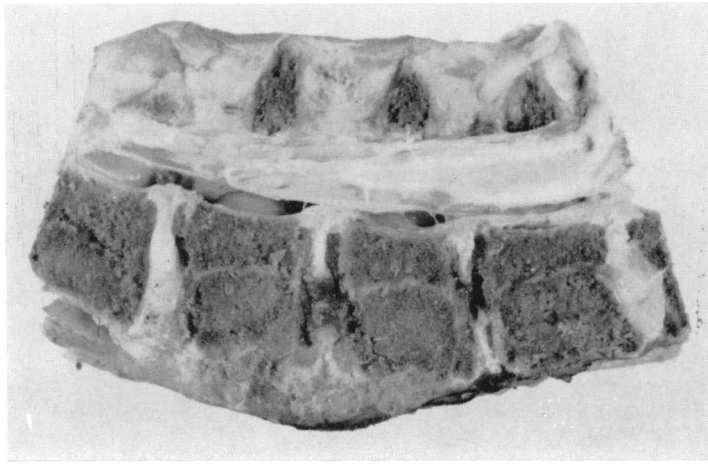


Fig. 6. Pig O. 528/61, neck with subacute discospondylitis in the 5th and 6th intervertebral spaces. Note the central cavity filled with necrotic and haemorrhagic disc and epiphyseal tissue.

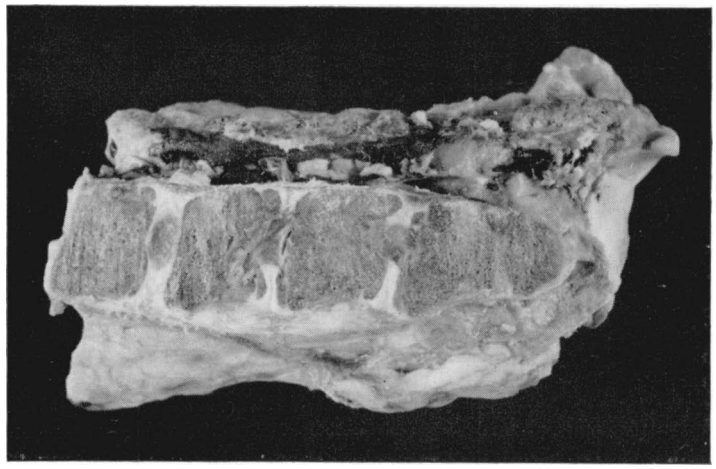


Fig. 7. Pig O. 531/59, neck with subacute discospondylitis in the 1st and 2nd intervertebral spaces. The intervertebral spaces and epiphyses of the vertebral bodies are partly destroyed and replaced by granulation tissue.

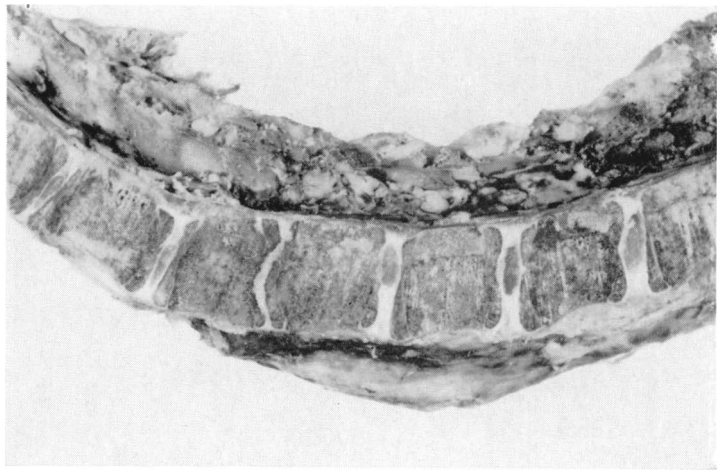


Fig. 8. Pig O. 532/59, neck with chronic discospondylitis in the 5th intervertebral spaces. The disc is very much narrower than normal and is distorted by pronounced destruction of the epiphysis of the immediately cranial vertebral body.

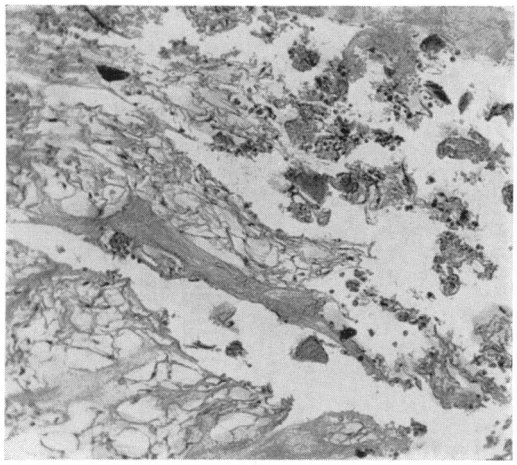


*Fig. 9 A*

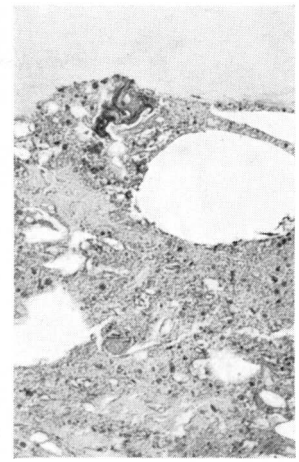


*Fig. 9 B*

Fig. 9. Pig O. 722/61, discospondylitis. Section from nucleus pulposus showing granular degeneration, haemorrhage, and neutrophil infiltration as well as degenerated fragments from the cartilage plate. Van Gieson, 110 ×.

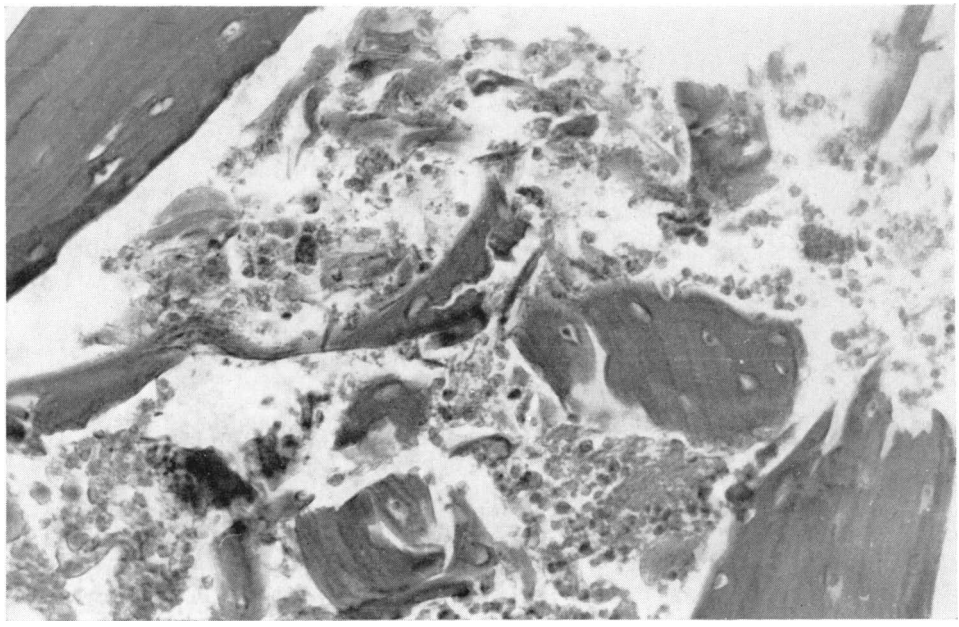


Fig. 10. Pig O. 722/61, discospondylitis. Section through the epiphysis of a vertebral body showing microfractures, osteolytic foci, haemorrhage, and neutrophil infiltration. Van Gieson, 300 ×.

Fig. 11. Pig O. 722/61, discospondylitis. Epiphysis of a vertebral body showing an island of nucleus tissue which has been forced in. Van Gieson, 240 ×.

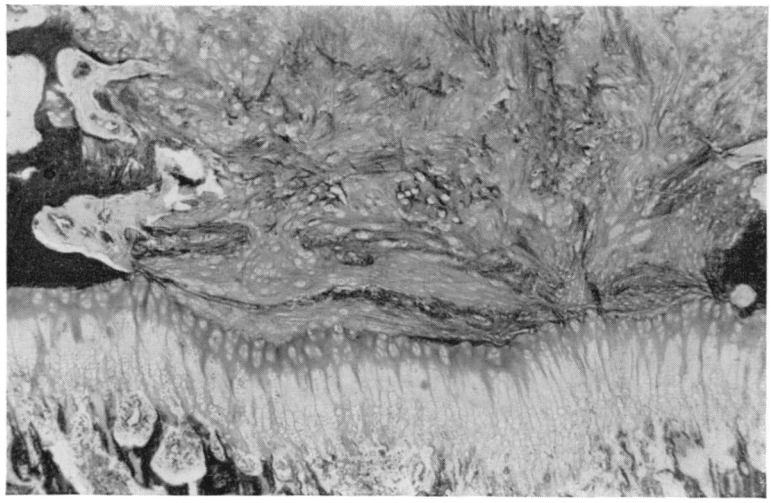


Fig. 12. Pig O. 8062/60, discospondylitis. Epiphysis of a vertebral body illustrating the disappearance of osseous tissue and its replacement by mixed cartilage and connective tissue (pannus formation) which, at the lower border of the figure, is in direct contact with the epiphyseal line. Van Gieson, 40 ×.

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## SUMMARY

Discospondylitis, usually involving several intervertebral spaces, was found in 27 of 44 pigs with infectious polyarthritis which in most instances was a manifestation of erysipelas. This paper is mainly concerned with the spinal lesions which seem to have escaped attention commensurated with their incidence. Clinical, röntgenological, pathological, and bacteriological aspects are discussed. The pathogenesis of the spinal lesions and their similarity to infectious discospondylitis in human beings, particularly children, are discussed.

## ZUSAMMENFASSUNG

*Discospondylitis und Arthritis beim Rotlauf der Schweine.*

Verfasser beschreiben 44 Fälle von infektiösen, in der Hauptsache durch Rotlauf verursachten Polyarthritiden beim Schwein. In 27 von diesen Fällen konnte ausserdem das Vorkommen von Discospondylitis und dabei öfter in einer grösseren Anzahl von Bandscheibenspalten festgestellt werden. Die Arbeit beschäftigt sich in der Hauptsache mit

diesen spinalen Veränderungen, denen im früheren Schrifttum nicht diejenige Aufmerksamkeit gewidmet worden ist, welche ihr häufiges Vorkommen eigentlich verdient. Die klinisch-röntgenologischen, pathologisch-anatomischen sowie bakteriologischen Befunde werden beschrieben. Die Pathogenese der spinalen Veränderungen und deren Ähnlichkeit mit den infektiösen Discospondylitiden beim Menschen und insbesondere beim Kind, wird besprochen.


## SAMMANFATTNING

*Diskospondylit och artrit vid rödsjuka hos svin*

Författarna beskriva ett material av 44 grisar med infektiösa, huvudsakligen rödsjukebetingade polyartriter. I 27 av dessa fall förelåg dessutom diskospondyliter i oftast ett större antal diskspalter. Arbetet sysselsätter sig huvudsakligen med dessa spinala förändringar, som i tidigare litteratur inte rönt den uppmärksamhet som deras frekvens uppenbarligen förtjänar. Beskrivningen är klinisk-röntgenologisk, patologisk-anatomisk och bakteriologisk. De spinala förändringarnas patogenes och likheter med infektiösa diskospondyliter hos människa, i första hand hos barn, diskuteras.


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