THE VASCULAR ANATOMY OF THE SPINE AND ITS RELATIONSHIP TO PYOGENIC VERTEBRAL OSTEOMYELITIS

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Since Batson (1940) drew attention to the paravertebral system of veins there have been a number of reports of cases of spinal osteomyelitis attributed to the spread of infection by venous route from the pelvis (Deming and Zaff 1942; Donohue 1949; Myrhe 1949; Hurwitz and Albertson 1950; Alderman and Duff 1952; Romanus 1953; Wood 1954; Mussey 1954; DeFeo 1954; Leigh, Kelly and Weens 1955; Henson and Coventry 1956; Lame 1956; Liming and Youngs 1956). A thorough review of the literature and a further contribution of five new cases has recently been made by Henriques (1958).

Harris (1941) pointed out that the paravertebral system of veins had been adequately described by Bock (1823) and by Breschet (1832), and that even earlier investigators were aware of it. It seems somewhat surprising that among the large series of cases of spinal osteomyelitis recorded before 1940—particularly those of Donati (1906), Volkmann (1915), Schwarz (1920), Wilensky (1934), Klein (1933), Kulowski (1936), Stammers (1938) and Turner (1938)—there have been only isolated instances of pelvic suppuration as a primary focus. Thus Kulowski, in sixty personal cases, saw a previous pelvic infection (prostatic abscess) in only one, and Stammers, in a smaller series, attributed the bony infection in one instance to a septic abortion.

In an attempt to define the pathway by which organisms may reach the spine the vascular anatomy of the adult vertebrae has been investigated, and the more pertinent features are here described together with implications of the paravertebral venous plexus. The case histories of nineteen patients treated for osteomyelitis of the spine at this Centre from 1944 to 1958 are reviewed.

For a comparison, the details of eighteen non-spinal cases of adult osteomyelitis are set out in table form. Finally the place of pelvic sepsis as a focus for osteomyelitis is discussed in the light of the anatomical and pathological findings.

THE VASCULAR ANATOMY OF THE SPINE

Text-books of anatomy (Cunningham 1937, Gray 1954) make scant reference to the small blood vessels to bone. Wilensky (1934), Willis (1949), Ferguson (1950) and Harris and Jones (1956) described the distribution of the small arteries to the vertebral column. The work of Lexer, Kuliga and Türk in 1904 provided the most detailed and consistent description of the minute nutrient vessels to bone. Batson's (1940) descriptions of the vertebral plexus need no confirmation. Anderson (1951) showed in living subjects that variations in abdominal pressure caused a varying flow of radio-opaque material through the large valveless vertebral plexus which connects freely with the central vein of the vertebral body. Nevertheless, Walldén (1952), investigating the causes of collapse of the rectum as it passes through the floor of the pelvis under certain circumstances, pointed out that an increase of intra-abdominal pressure caused a collapse phenomenon wherever intestines or vessels pass out through the abdominal wall or into tissues or organs with a lower pressure. " There can hardly be a flow of any considerable amounts of blood from the abdominal and pelvic cavities to the vertebral veins in straining, and in any event they will not be emptied."

The vertebral veins were studied by Anson, Cauldwell, Pick and Beaton (1948) during dissections of over four hundred cadavers. These authors depicted the central vertebral veins

as large channels freely communicating through the cortex of the vertebral body with the tributaries lying thereon. They failed to find any direct venous communication between the (right) renal vein and the paravertebral plexus. This observation is referred to later.

Anatomical studies—We have investigated the blood supply, both arterial and venous, of the human and animal (rabbit) vertebral column* in order to define exactly the minute vascular anatomy.

Material—Twenty-five cadavers were studied. One subject was aged fifteen, one was twenty and the remaining twenty-three were over thirty years of age. No subject was rejected on the grounds of disease, but the younger cadavers were injected with more ease than the elderly and were used more extensively in the subsequent bony study.

Method of preparation—To fill the arterial side the aorta was isolated by ligation above the bifurcation and below the renal vessels. Preliminary washing out of the vascular system was found to be unnecessary. About a litre of " Micropaque " barium suspension was injected

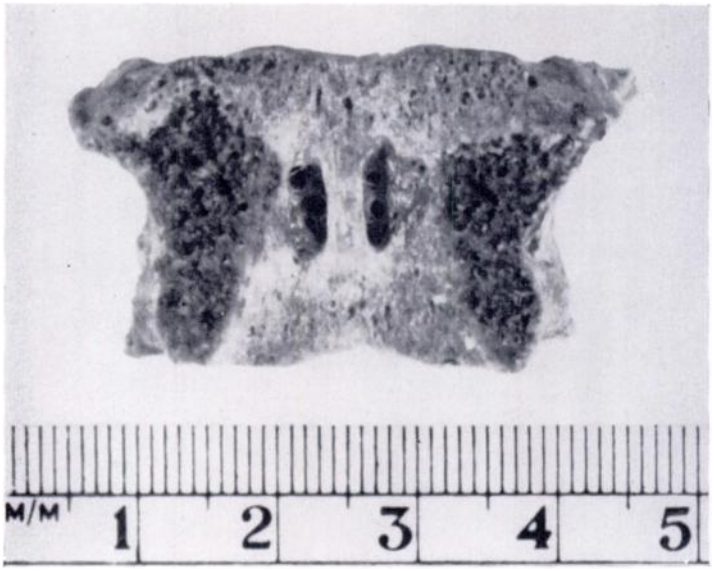

FIG. 1
The dorsal surface of the tenth thoracic vertebral body showing the large nutrient foramen.

into the isolated aortic section with a large metal syringe. As is the usual practice at this Centre (Trueta and Harrison 1953, Trueta 1957), the injection was done slowly and at room temperature.

The venous system was injected in a similar way. A segment of the main pelvic venous network was isolated by ligating the external iliac vein and the confluence of the common iliac veins. The segment was cannulated and a litre of " Micropaque " slowly injected with the body supine. Fluid quickly emerged from branches and tributaries in each case. Each leak point was clamped. To ensure bony filling from the venous plexus, we clamped the spinal cord in the lower thoracic region at the close of the venous injection and increased the pressure in the injecting syringe so that the suspension flowed freely from the surface of the vertebral bodies and from every neighbouring minute tributary.

In the cadavers of three rabbits similar experiments were carried out: the rapid appearance

* A paper from this Centre on the vascular anatomy of the rabbit's spine is published elsewhere in this issue (Amato and Bombelli, page 782). Work is also in progress on the vascular anatomy of the spine in dogs.

of suspension in the basal cerebral sinuses was a feature in the venous injections of these animals.

After the injection had been completed segments of the cervical, thoracic and lumbar vertebral column were removed and immersed in decalcifying agent (10 per cent nitric acid). After decalcification, horizontal and vertical slices a centimetre thick were cut from the vertebral bodies. Each slice was subjected to fine-grain radiography (using a cobalt tube) and was then immersed in Spalteholz solution, which made it possible, under the dissecting microscope, to trace the course taken by the minute vessels to and within the bone.

Observations—The arrangement of the nutrient vessels is similar in the cervical, thoracic and lumbar vertebral regions: a vertebral, intercostal or a lumbar artery lying close against each vertebral body supplies to the nearby bone minute vessels which penetrate directly the cortex and ramify within the underlying marrow. In addition, at each intervertebral foramen a

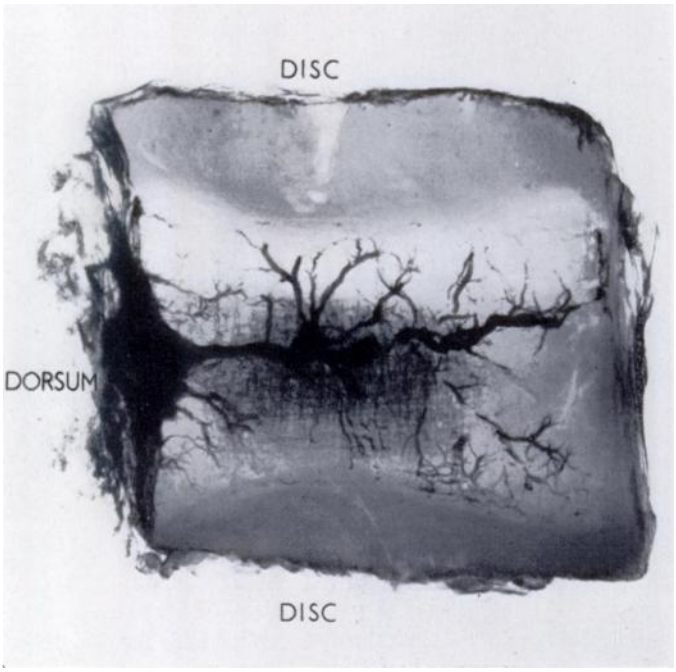

FIG. 2
Vertical section through body of second lumbar vertebra, showing the vertebral extension of the venous plexus.

posterior spinal branch enters the vertebral canal and divides into an ascending and a descending branch. Each branch anastomoses with those from the segments above and below, and from the other side, forming thereby an arterial network on the dorsal, or posterior, surface of each vertebral body. From this network are given off some three or four nutrient arteries which enter the vertebral body through a large centrally placed nutrient foramen in the dorsal surface of the bone (Fig. 1).

The venous drainage of the vertebral body is tree-like in its arrangement as seen on vertical section (Fig. 2). From the metaphysis minute tributaries drain to the centre of the vertebral body, being collected into a large valveless venous channel which emerges from the central dorsal nutrient foramen and drains into a vast loose plexus lining the vertebral canal. The tributaries of the vertebral body are connected, through the bony cortex, by channels of inconstant size and site, with the veins lying on the abdominal and lateral surfaces of the

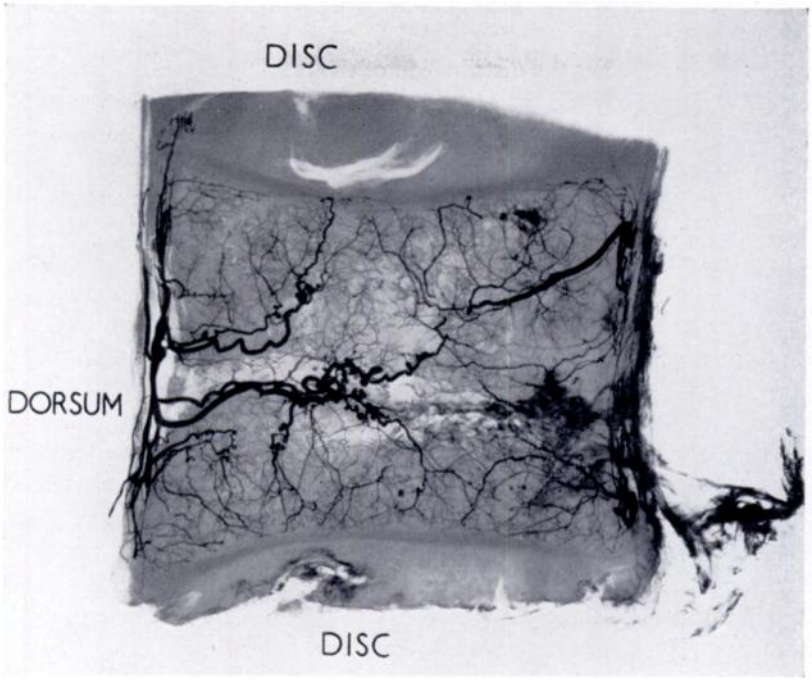

FIG. 3
Vertical section through the body of the second lumbar vertebra, showing the distribution of the nutrient arterioles.

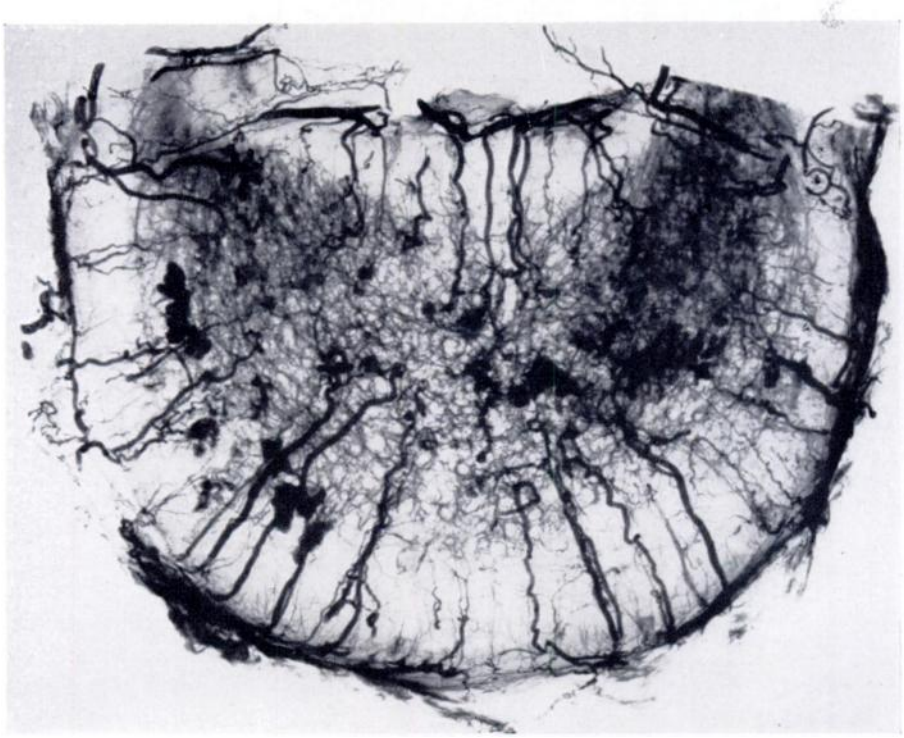

FIG. 4
Horizontal section through the body of the second lumbar vertebra of an elderly adult, showing senile hyperaemia.

vertebral bodies. This paraspinal and spinal venous plexus constitutes Batson's vertebral plexus.

Within the vertebral bodies the distribution of the nutrient arterioles is seen from Figures 3 and 4. The posterior spinal arterioles anastomose freely with those entering the bone more directly from the segmental artery. We were struck by the increased vascularity of specimens obtained from elderly subjects (Fig. 4).

Comment—Our injections showed that the bony tributaries of Batson's plexus were smaller than expected and tail off to the metaphysis as minute twigs, here and there communicating through the substance of the vertebral body with the veins lying on the abdominal surface of the bone. These tributaries of the venous system were filled only with considerable difficulty and under pressure. A number of imperfect venous injections were encountered. Contrariwise, the arterial injections were performed with ease and showed well the vascularity of the vertebral metaphysis.

By this series of injections we have demonstrated to our own satisfaction that there are available two direct routes for the spread of disease processes to the vertebral marrow: the nutrient arteries of easy access, and the much less accessible paravertebral venous system.

CLINICAL CASE REPORTS

Case 1—A man aged fifty was admitted in November 1956. He had sustained a traumatic rupture of the urethra thirty-three years before, and had developed a stricture which required repeated dilation. This was complicated by peri-urethral abscesses, and by vesical stones which required surgical removal. The last episode resulted in acute retention, with a further peri-urethral abscess; so a suprapubic cystotomy was performed and the urethra dilated. About two weeks later he developed pain in the neck and left shoulder. He was transferred to this Centre. His temperature was 100·8 degrees Fahrenheit and pulse rate 96 per minute. He was mentally confused. There was tenderness over the spines of the fifth, sixth and seventh cervical vertebrae and to a lesser extent over the upper thoracic spinous processes. There was hyperaesthesia in the distribution of the sixth cervical nerve in the left arm. The urine was acid and contained pus. The blood urea was 26 milligrams/100 millilitres. Acute osteomyelitis of the cervical spine was diagnosed, but no bony disease could be identified on radiography.

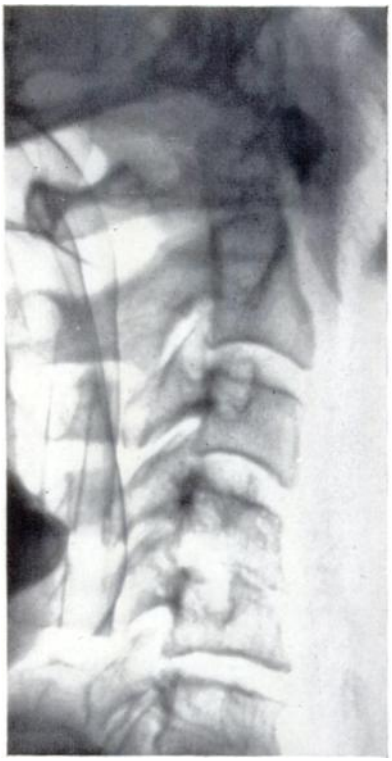

FIG. 5

Case 1—Lateral radiograph showing early destructive pyogenic lesion of the fourth and fifth cervical vertebrae and the intervening disc.

The patient was put on a plaster-of-Paris bed and penicillin (1,000,000 units three-hourly) was administered, but without effect. Aureomycin (250 milligrams four-hourly) was then given. The bladder was washed out. *Progress*—Leucopenia, with total white cell count of 1,800 per cubic millimetre (polymorphonuclears 560 per cubic millimetre), developed. There was a slight general improvement within ten days, but pyrexia recurred, with pain in the right eye. Acute irido-cyclitis was diagnosed, for which he was given local atropine and cortisone. Three weeks later the haemoglobin had fallen and neutropenia persisted. Marrow puncture suggested aleukaemic leukaemia. Blood transfusions were given. The general condition gradually deteriorated and the eye infection progressed: staphylococcus aureus—resistant to

penicillin and to aureomycin—was grown from the eye, which was later eviscerated. At this time the blood urea was increased, and radiographs of the cervical spine showed an infective process between C.4 and C.5, with a reduction of disc space and destruction of the end plates (Fig. 5). The patient died four weeks after admission.

At necropsy the adjacent sides of the bodies of C.4 and C.5 vertebrae and the intervening disc were found to be completely destroyed. There were thrombotic vegetations on the tricuspid valve, and the red bone marrow had increased in extent. No record was made of changes in the vertebral venous plexus.

The relevant details of the other eighteen cases of pyogenic spinal osteomyelitis are set out in Table I. In Cases 1, 5 and 9 and Cases 12 to 15 the spinal infection followed pelvic sepsis.

Table II shows the principal features of the " non-spinal " osteomyelitis of adults. It is seen that the lesions were found in the sites of residual red marrow. With the exception of one anaerobic streptococcal infection, one due to bacillus aerogenes and one due to a mixed infection of gram-negative bacilli, the staphylococcus aureus was the infecting agent. In several patients the course, like that in spinal disease, was subacute or chronic. Visceral primary foci were identifiable in at least two instances (Cases 13 and 15).

In a total series of thirty-three adult patients suffering from osteomyelitis (all bones) there were examples of sinusitis, chest infection, cholangitis and genito-urinary infections acting as primary foci, giving rise to bouts of septicaemia, particularly after instrumentation. Of these internal foci urinary tract infections preponderated and the spine was most commonly affected.

DISCUSSION

There is much clinical evidence of a relationship between the genito-urinary system and the vertebral column, as exemplified by the spread of prostatic carcinoma and the finding of urinary infection in patients with ankylosing spondylitis. Yet we are not aware of any work which has succeeded in establishing the existence of any pathway other than the expected one—the peripheral arterial network—in the spread of pelvic sepsis to vertebrae.

In the adult the red marrow shrinks to occupy only the vertebral bodies, ribs, skull, pelvis and ends of long bones; this and the disappearance of the vascular barriers constituted by the epiphysial cartilages explains why osteomyelitis becomes rare in adults but in them is found most frequently in the spine.

From 1944 to 1958, of 202 patients with acute osteomyelitis seen at this Centre, thirty-three aged sixteen and over suffered from pyogenic osteomyelitis (all bones). In over fifteen of these adults the lesions were in the vertebral column.

The features of vertebral disease in our cases coincide with those described by Wilensky (1929), Kulowski (1936), Stammers (1938) and Turner (1938). Vertebral osteomyelitis in its more acute form is seen in the young, when the organism is usually a staphylococcus. In the adult the organism may be a gram-negative bacillus and the process less active. Spines, laminae or vertebral bodies may be affected. In the more chronic forms vertebral bodies are affected. The process tends to affect the more mobile spinal segments—those of the lumbar and lower cervical regions. Spread to the meninges may occur.

It does not seem surprising that, of all the red marrow in the adult, that of the spine is the most readily affected by pyogenic infection.

The literature indicates that pelvic primary foci are not necessarily confined to the urinary tract. O'Leary, Lipscomb and Dixon (1954) reported a case of spinal osteomyelitis complicating a pelvic enteric fistula. Sherman and Schneider (1955) reported examples after septic abortion and puerperal sepsis. Lame (1956) had two cases: one followed abdomino-perineal excision of the rectum; the other followed excision of sigmoid polypi. Among the cases preceded by urinary disease no specific urinary infection, operation or manipulation can be singled out as predisposing to osteomyelitis.

TABLE I

CLINICAL DETAILS IN NINETEEN CASES OF SPINAL OSTEOMYELITIS (1944–1958)

Case number	Sex	Age (*years*)	Site of lesion	Primary focus	History of trauma	Interval between primary activity and onset
1	M	50	C.4–5	Peri-urethral abscess	No	Infective episodes for many years
2	M	53	L.2–3	Carbuncle neck	Not recorded	4 weeks
3	F	15	L.4–5	None recorded	No	Not recorded
4	F	12	T.4–5	? Upper respiratory infection	No	10 days
5	M	61	L.2–4	Wounds of pelvis during 1914–18 war: paraplegia. Residual renal infection with repeated exacerbations	Yes	Doubtful
6	M	50	L.3–4	None recorded	Not recorded	Not recorded
7	F	73	L.3–4	Doubtful. Osteomyelitis ulna 20 years ago but no clinical evidence of activity	Not recorded	Not recorded
8	F	9	Laminae of lower thoracic vertebrae	Not known	Not recorded	Not recorded
9	M	42	T.6–7	Congenital urethral stricture and imperforate anus treated in infancy. Vesical calculosis; bladder diverticulum; left hydronephrosis; chronic left epididymitis	Not recorded	Doubtful
10	M	44	T.8–9	Possibly upper respiratory infection	Not recorded	2 weeks
11	M	11	Thoracic processes (upper)	Septic abrasion knee	Fall on to feet	5 weeks
12	M	67	T.7–8	Prostatectomy (retropubic)	Fall in ward	3 weeks
13	M	57	C.6	Urethral stricture: recent dilation followed by haemorrhage	No	2 days after dilation
14	F	50	T.12–L.1	Bilateral hydronephrosis and hydro-ureter. Flares of renal infection. Right uretero-enteric anastomosis	No	Weeks
15	M	49	T.12–L.1 L.3–4	Old venereal urethral stricture dilated; " septicaemia " and pneumonia followed	Possible	About 12 weeks
16	F	65	L.3–4	? Respiratory. Cough; purulent sputum	1) Fall; 2) flexion strain	5 weeks
17	F	59	L.4–5	? Respiratory. Chest pain at onset, with rhonchi	No	Uncertain
18	M	50	L.5–S.1	None recorded	Not recorded	Not recorded
19	F	68	T.12–L.1	Stone in common bile duct with Charcot's triad	Not recorded	1 month

TABLE 1—*continued*

Primary lesion	Organism: Blood	Organism: Bone	Treatment	Result	Additional features
Not recorded	Not recorded	Not recorded	Plaster bed; penicillin; aureomycin	Died	Staphylococcal irido-cyclitis developed; eye eviscerated. Fulminating infection. See text
?	?	?	Penicillin; plaster jacket	Recovery	Subacute
?	S. aureus	?	Penicillin; plaster bed	Recovery	Very acute
?	?	S. aureus	Penicillin; drainage	Paraplegic	Extremely ill and paraplegic on admission
?	—	Micrococci	Penicillin; drainage	Returned to fair health	Chronic. Before admission had many episodes of spinal suppuration with spontaneous discharge of pus
?	?	?	Penicillin; plaster	Complete recovery	Fifteen years before, and at onset of illness, had short attack of dysuria. No urinary abnormality discovered
?	?	?	Penicillin; plaster	Recovery	—
?	?	S. aureus	Penicillin; aspiration	Full recovery	Subacute
Mixed gram-negative bacilli (urinary)	?	?	Chloromycetin; bed rest	Full recovery	Onset of spinal lesion obscure. Admitted with paraplegia. This settled quickly under antibiotics. Bladder stones removed later
?	?	?	Penicillin	Full recovery	Urine normal
?	? S. aureus	?	Penicillin	Full recovery	—
?	?	?	Plaster bed	Full recovery	Orbital infection while on plaster bed; spontaneously improved. Also epididymo-orchitis
?	?	?	Erythromycin; plaster collar	Full recovery	Initial symptoms severe and accompanied by spastic hemiparesis right arm
B. coli	?	?	Streptomycin; plaster	Eventual recovery	Empyema of gall bladder during convalescence. Recent evidence of renal calculus
B. coli	?	Micrococci	Penicillin; tetracycline	Recovery	Developed costochondral infection at third right rib; P. pyocyanea isolated
?	?	?	Penicillin; frame	Recovery	Symptoms suggestive of chronic cholecystitis
?	?	?	Archomycin; plaster bed	Recovery	Urine contained S. aureus. No urinary symptoms
?	S. aureus	Staphs.	Penicillin; aureomycin; multiple incisions	Still active	Acute onset with pneumonia and meningitis. Previous pericarditis and pleurisy
?	?	?	Penicillin	Still active	Back pain came on gradually after an episode of abdominal pain accompanied by " collapse "

TABLE II

CLINICAL DETAILS IN EIGHTEEN CASES OF OSTEOMYELITIS (ALL BONES) IN PATIENTS OVER SIXTEEN (1944–58)

Case number	Sex	Age (*years*)	Site of lesion	Primary focus	History of trauma	Interval: primary activity to onset
1	M	53	Left fibula	? Boils	No	Months
2	M	51	Right femur	Boils on arms	No	3 weeks
3	M	31	Left ulna	Boil on arm	No	1 week
4	F	31	Right femur	Diarrhoea; stools not examined	No	Not recorded
5	M	17	Left tibia	Boils; stye	No	?
6	F	55	Right femur	None found	No	Not recorded
7	M	35	Left ulna	Boils on elbow and forearm	No	1 month
8	M	43	Pelvis	?	Fall	Not recorded
9	M	50	Tibia	?	Not recorded	?
10	F	37	Right clavicle	?	Carrying wood on shoulder	9 days
11	M	16	Right second metacarpal	?	Not recorded	?
12	M	64	Left femur	Possibly in tibia where an abscess existed 30 years before	Blow on knee	7 weeks
13	—	—	Right radius	Ethmoiditis, bronchiectasis. Empyema treated by rib resection but developed broncho-pleural fistula	Not recorded	4 months after rib resection
14	M	17	Right humerus	?	Not recorded	?
15	F	34	Left tibia	Gynaecological operation	Not recorded	4 weeks
16	M	48	Left humerus	?	Not recorded	Not recorded
17	M	52	Medial sesamoid of hallux	Not recorded	Not recorded	Not recorded
18	M	19	Ilium	?	Twisted leg	5 weeks

Before the publication of Batson's work the association between internal—particularly genito-urinary—foci and the osteomyelitis of adults had not been fully appreciated, despite its having been observed by Klein (1933), Selig (1934), Schein (1940) and others.

Our own cases and many of those collected from the literature belong to the antibiotic era. Before this, as Reid (1958) pointed out, deaths from septicaemia occasionally followed genito-urinary manipulations, when the presence of a bone marrow infection may have been obscured by the signs of overwhelming general sepsis. Moreover in septicaemia symptoms

TABLE II—*continued*

Primary lesion	Organism: Blood	Organism: Bone	Treatment	Result	Additional features
?	None	S. aureus	Penicillin; incision	Cured	Chronic infection. Previous dysuria, but urine normal
?	?	S. aureus	Penicillin; sequestrectomy	Cured	Extensive deep venous thrombosis
?	?	S. aureus	Penicillin; incision	Cured	—
?	S. aureus	S. aureus	Penicillin; incision	Cured	Urine normal
?	?	S. aureus	Penicillin; incision	Cured	—
?	None	S. aureus	Penicillin, aureomycin; incision	Cured	Ureteral injury during hysterectomy 10 years before. Right kidney enlarged. No urinary symptoms
?	None	S. aureus	Penicillin; incision	Cured	—
?	None	Gram-negative bacilli, proteus+ pyocyanea	Excision of pubic sequestrum; aureomycin; streptomycin	(Inadequate follow-up)	Chronic infection. Many sinuses in groins and buttocks. B. proteus isolated from urine
?	B. aerogenes	?	Penicillin	Cured	—
?	None	S. aureus	Penicillin; incision	Cured	—
?	None	S. aureus	Penicillin; incision	Cured	—
?	?	S. aureus	Penicillin; incision	Pathological fracture; eventual healing	Urine normal
Anaerobic strep.	None	Anaerobic strep.	Penicillin drip; 3 drainage operations	Cured	—
—	S. aureus	S. aureus	Penicillin; drainage	Cured	—
?	None	?	Penicillin; incision	Cured	—
?	?	S. aureus	Penicillin; incision	Cured	Previous history of sepsis after gastrectomy and meniscectomy
?	None	S. aureus	Penicillin; excision	—	Doubtful case
?	S. aureus	S. aureus	Penicillin; incision	Cured	—

of nephritis may occur; so urinary abnormalities found during the height of a fever should be interpreted with reserve. Kulowski (1936) pointed out that extension of pyogenic spinal infection anteriorly from the vertebral body is common. This may lead to pleural, pericardial or retroperitoneal abscess formation with " perinephric collections." Carson (1931) recorded a case of prostatic abscess accompanying spinal osteomyelitis and probably merely just another septicaemic focus. From all this it seems clear that the association of spinal suppuration with pelvic sepsis must be interpreted with care.

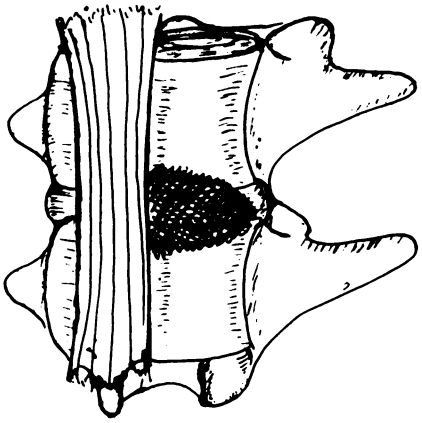

FIG. 6
The usual site of pyogenic osteomyelitis in the spine.

Acute osteomyelitis is by nature haematogenous, through nutrient vessels, and to postulate a spread to the spine by a venous route implies "spread by extension"—the term used by Wilensky (*loc. cit.*) in describing diploic spread in the skull. Nevertheless we see no objection to a conception of spread by this route elsewhere than in the skull, provided pathological and anatomical considerations are satisfied. These possibilities are now explored.

Coman and de Long (1951) proved that malignant disease can spread from the pelvic veins into the vertebral bodies through the paravertebral plexus in a series of experiments on animals in which the inferior vena cava was clamped. The sections showed malignant cells growing from the centre of the vertebral body into the metaphyses. Yet Collis (1944) was unable to spread infection through Batson's plexus in his series of animal experiments. A study of our own injection material suggests that the venous system of the vertebral bodies is in fact a drainage system and may be filled in a retrograde fashion only by pressure; that the drawings of Anson, Cauldwell, Pick and Beaton (1948) have given an erroneous impression of the size of the bony veins and particularly of the connections with the vertebral body surface; and that the to-and-fro tide of blood from spinal canal to exterior through the vertebral body has been exaggerated. We cannot find any anatomical ground for believing that a right renal infection can spread to the paravertebral system (Table I, Case 13), and Anson *et al.* failed to locate a connection between the right renal vein and the paravertebral system.

It is fortunate that in the recorded cases of osteomyelitis complicating pelvic sepsis, and in all our own cases, there have been available radiographs indicating the site of the vertebral lesions. Without exception this has been at the metaphysial area, and (in early radiographs) close to the anterior longitudinal ligament (Figs. 6 to 8). This region is richly supplied by nutrient arterioles from the surface and from the main nutrient artery entering through the posterior vertebral nutrient foramen. It is here that the tubercle bacillus settles and, in the elderly, that vascular osteophytes form.

The lesion appears to spread quickly across the periphery of the disc, where anastomoses exist, and to involve the metaphysis of the adjacent vertebra above. Sometimes two separate pairs of vertebrae are affected, or even three in succession. This distribution suggests an arterial spread through ascending and descending nutrient branches of the posterior

FIG. 7
A typical pyogenic lesion of the second lumbar vertebra.

spinal arteries. Eventually the lower vertebra undergoes pressure collapse, and spontaneous spinal fusion occurs (Fig. 9). We doubt whether this segmental process, distributed to the metaphyses, could follow backflow into minute metaphysial tributaries of the paravertebral venous plexus. Moreover, the onset of spinal symptoms in most of our cases was preceded by "chills" or "fevers," suggesting haematogenous osteomyelitis. Again, no evidence of meningism was recorded in any of our cases to suggest a spreading extradural thrombophlebitis; nor has this been recorded in the published reports—a most peculiar immunity if the spread of infection was by the spinal veins.

Evidence of the frequency with which urinary infection causes spread through the general circulation is found in the work of Barrington and Wright (1930), who obtained positive

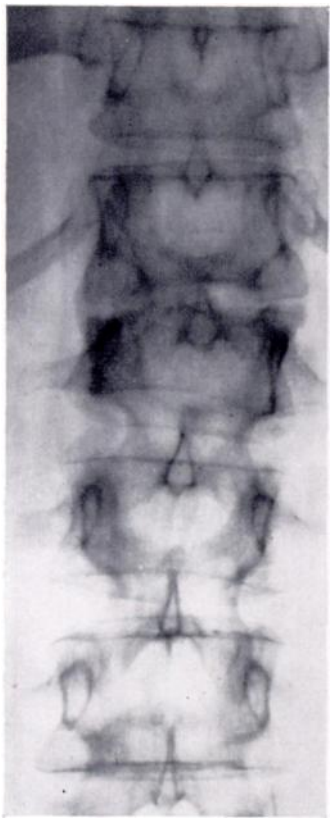

FIG. 8

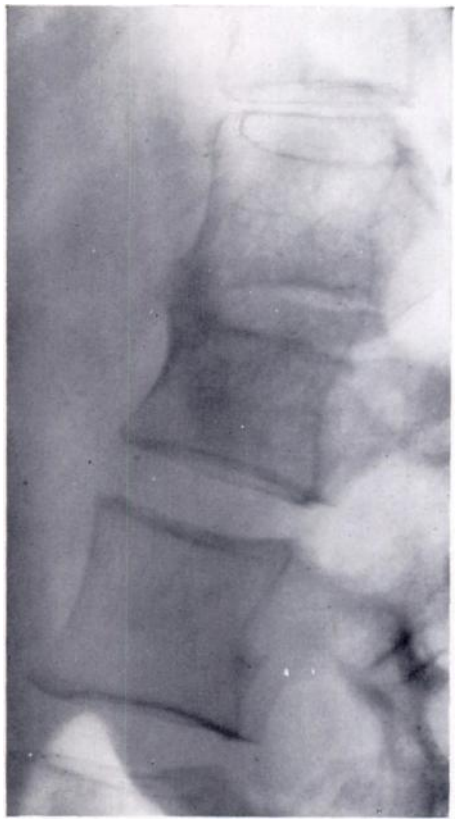

FIG. 9

Figure 8—Pyogenic lesion of upper metaphysis of the first lumbar vertebra on the right side. Figure 9—Healed pyogenic lesion, with spontaneous bony fusion.

blood cultures after even mild urinary manipulations such as ureteric catheterisation. Since no case of pelvic thrombophlebitis was reported it may be assumed that the bacterial invasion had followed the usual path from the lymphatic to the general circulation, and was not related to the peculiar venous backflow.

Thus, although there exists an open pathway by which infection from the parietes and viscera might enter the vertebral bodies it seems unlikely, on pathological and anatomical grounds, that spread by this route in fact occurs. Reid (1958) and Masina (1958) had never seen a case of vertebral osteomyelitis complicating the many hundreds of prostatectomies performed by them in a total of nine different hospitals. This emphasises the rarity of the condition, and, as it is difficult to conceive that sepsis never arose after these operations, we may conclude that the paravertebral plexus is not used by organisms travelling to the bone marrow.

SUMMARY

1. Vascular anatomical studies of the spine are described and the possibility of spread of infection from pelvis to spine through the paravertebral venous plexus is discussed.
2. Though a venous route does exist, our studies do not support the supposition that infection is likely to spread by this route; nor is there any clear clinical, pathological or anatomical evidence that such spread occurs.
3. Nineteen cases of pyogenic osteomyelitis of the spine are recorded, six of which followed urinary infections. The condition is compared with osteomyelitis as it occurs in the other bones of adults.

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