20.3 Osteomyelitis 4688

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ESSENTIALS Bacteria can penetrate bone from a contiguous focus of infection (e.g. a diabetic foot ulcer or local injury) or by haematogenous spread. Osteomyelitis is most commonly caused by Staphylococcus aureus, β-haemolytic streptococci, and—in some situations—aerobic Gram-negative rods. An acute inflammatory response causes oe- dema within bone and soft tissue, and thrombosis in vessels that can result in bone infarction. Pus may form within cancellous bone and beneath the periosteum, stripping it from the bone and leading to extensive necrosis that sometimes involves an entire bone. The pro- cess may become chronic and relapsing. Definitive diagnosis can only be confirmed with culture of bacteria from representative bone samples, supported by histological evidence of inflammation. This cannot be achieved in all cases and diagnosis is commonly made on the basis of clinical features and imaging. Magnetic resonance imaging is the standard and best method. Acute osteomyelitis Clinical features—the condition predominantly affects the metaphyses adjacent to large weight-bearing joints, presenting as rapid onset of pain and loss of function in the affected limb, usually accompanied by high fever and malaise. It is common in children and older people, often presenting after a history of minor trauma. Treatment—acute osteomyelitis is an orthopaedic and med- ical emergency. Diagnosis should be established rapidly by biopsy. Antibiotics (probably for at least four weeks) should be initiated on clinical suspicion, with appropriate initial regimens in most cases being a cephalosporin, a β-lactam/β-lactamase combination, or the combination of an antistaphylococcal penicillin and gentamicin. Vancomycin or an alternative will be necessary if the patient has risk factors for infection with methicillin-resistant S. aureus. Surgery is in- dicated if abscesses are present, or if the patient is failing to respond to medical measures. Chronic osteomyelitis Clinical features—presentation is more variable than acute osteomye- litis, but is typically painful unless there is underlying neuropathy. Wound or sinus tract drainage is usually present when the condition complicates ulceration, injury, or other surgery. The condition may be present for decades with periods of sinus discharge alternating with periods of few symptoms. Treatment—chronic osteomyelitis usually requires both (1) surgery— to remove dead bone and soft tissue, drain abscesses, eliminate cavities, ensure skeletal stability, and restore soft tissue cover; and (2) antibiotics—as above, but guided by culture results, for weeks to many months. Prognosis—a positive and coordinated approach from a multidis- ciplinary team can produce good results (90% cure rate with acute osteomyelitis and 80–90% with chronic osteomyelitis), a fact that stands in contrast to the negative experiences or views of many pa- tients, carers, and healthcare workers. Introduction and historical perspective Osteomyelitis is an ancient disease with a formidable reputation for persistence and relapse. The changes of chronic osteomyelitis are even apparent in some dinosaur fossils, most notably in the fibula of a Tyrannosaurus rex specimen

displayed in Chicago. It has been diagnosed in human fossil remains from the late Neolithic period and was described by many classical medical writers including Hippocrates. While the term indicates inflam mation of the marrow (the suffix ‘myelitis’) due to infection, it will be used here to indicate any infection of bone, even if confined to the cortex (sometimes called ‘osteitis’). In recent years, it has become clear that osteomyelitis should be managed by committed multidisciplinary teams which provide the skills to deal with all aspects of the disease and associated patient co-morbidities. As a minimum, this should involve orthopaedic sur geons, plastic surgeons, specialists in infection, radiologists, patho logists, therapists with skills in physical rehabilitation, and—as appropriate—adult physicians or paediatricians. Aetiology, pathogenesis, and pathophysiology The pathogens causing osteomyelitis are dominated by Staphylococcus aureus, which causes half of all vertebral osteo myelitis and one in three of all acute cases. Many other pathogens have been described and particularly chronic osteomyelitis may be polymicrobial (Fig. 20.3.1). 20.3 Osteomyelitis Martin A. McNally and Anthony R. Berendt

20.3 Osteomyelitis 4689 The critical step in pathogenesis is the access of bacteria to the bone. Healthy bone is usually very resistant to infection and is diffi cult to infect in experimental models. Osteomyelitis most commonly occurs after trauma, surgery, ulceration, or adjacent soft tissue infec tion (contiguous focus osteomyelitis). Previously, haematogenous infection was common with bacteria reaching the bone through the bloodstream in bacteraemic patients. The exact mechanism by which this occurs is uncertain. It is believed that the tortuous capillary loops in the metaphyses of the long bones, a favoured site for haematogenous osteomyelitis, are particularly vulnerable to thrombosis, which provides a site for bacterial seeding. This is sup ported by a history of recent blunt trauma to the affected part in some 30% of haematogenous cases and by observations that in most animal models it is necessary to injure bone to infect it. Even minor bone and soft tissue trauma exposes components of blood clots, the extracellular matrix, and the bone matrix to the bloodstream. Other α-haemolytic Streptococci Staphylococcus aureus Groups A, G Streptococcus Escherichia coli and other aerobic Gram-negative rods Group B Streptococcus Haemophilus spp. Streptococcus pneumoniae Enterococcus spp. Corynebacterium spp. Coagulase-negative Staphylococci Neisseria gonorrhoeae Kingella kingae Salmonella spp. Pseudomonas aeruginosa Burkholderia pseudomallei Brucella spp. Borellia burgdorferi Treponema pallidum Clostridium spp. and other anaerobes Mycobacterium tuberculosis Sporothrix schenkii Candida spp. Actinomyces, Nocardia, and Streptomyces spp. Special features, risk factors or anatomic sites ? preceding minor trauma or skin lesion for primary acute In adults, haematogenous infection especially in spine Neonates, pregnancy, diabetes, cancer, alcohol H. influenzae in unimmunized Endocarditis in native joints Role in osteomyelitis unclear unless diabetes, metalware or dead bone Primary disease rare Geographical and socio-economic factors Rare, increasingly isolated in children Sickle cell anaemia Disc space, symphysis pubis, MTPJ. IVDU, dialysis, chronic wounds, penetrating injuries, = Melioidosis. SE Asia. Diabetes and immunosuppression Mediterranean littoral and tropics = Lyme disease. East coast USA, arboreal Europe = Syphilis. Late tertiary disease Contaminated wounds Exposure to open TB; geographical and socio- economic factors. HIV Gardening, forestry Immunosuppression, multiple operations and antibiotic courses, IVDU Mycetoma (actinomycetoma, i.e. bacterial). Tropics Pseudallescheria boydii, Madura madurellae, others Blastomyces and Histoplasma spp., Coccidiodes imitis Antibiotic resistant strains (MRSA, MRSE, VRE) Mycetoma (eumycetoma i.e. fungal). Tropics N. America Prior hospitalization, multiple antibiotic courses, surgery N = Neonate, Ch = Child, A = Adult, B = Bone, J = Joint, N = Native, P = Prosthetic, H = Haematogenous, C = Contiguous, IVDU = intravenous drug user, MTPJ =

metatarsophalangeal joint, MRSA = methicillin resistant Staphylococcus aureus, MRSE = methicillin resistant Staphylococcus epidermidis, VRE = vancomycin resistant Enterococcus Acute Chronic N A J B J B J B B J All ages N P H C ? preceding minor trauma or skin lesion for primary acute Role in osteomyelitis unclear unless diabetes, metalware or dead bone Ch N P Well recognized, but less common Very or relatively common, should always be considered Rare, seen in specialized practise or specific contexts Fig. 20.3.1 Microbiological causes and contexts in pyogenic arthritis and osteomyelitis.

SECTION 20 Disorders of the skeleton 4690 Many pathogens, notably S. aureus, can adhere to such host proteins through specific receptors and, hence, to tissues and cells, including endothelial cells and osteocytes. An acute inflammatory response is elicited once bacteria gain ac cess to bone and begin to multiply. This causes oedema within bone and soft tissue, and the procoagulant effect of inflammation may also cause thrombosis in vessels. The result can be bone infarction, possibly contributed to by bacterial toxins. As infection progresses, it propagates within the bone marrow and through the cortical bone via the Haversian canals. Pus may form within cancellous bone and beneath the periosteum (see Fig. 20.3.2 for a schematic diagram). It may break into the soft tis sues and even extend to the surface as a sinus tract. Subperiosteal pus under pressure will strip off the overlying periosteum, tracking along the length of the bone and around its circumference. The vascular consequences of this are critical to the evolution of the disease, since the outer aspect of the cortical bone is vascular ized by the periosteum, the inner by the endosteal circulation. If the endosteal blood supply is already compromised by the infec tion, periosteal stripping causes bone death. Thus, large pieces of bone, segments, or even whole long bones can die as the infection progresses. Dead bone can potentially be revascularized and remodelled, but only if it remains in physical continuity with living bone. However, the action of bone-resorbing cells, recruited and acti vated by inflammation and some bacterial products, is frequently to separate dead from healthy bone. This produces a detached piece of dead bone called a sequestrum. Small sequestra can be extruded through sinuses or wounds and the episode of osteo myelitis may arrest spontaneously; larger sequestra result in con tinuing infection and inflammation. Over time, more bone tends to be involved, sometimes resulting in new sinuses, with exten sion into soft tissues and contiguous joints. As bone is resorbed and killed, the resulting loss of strength may lead to pathological fracture. Chronicity and relapse result both from this host response and from features of bacterial physiology. The body cannot mount ef fective inflammatory responses in dead tissue or chronic abscesses. Bacteria adhere to the inanimate surfaces of dead bone and, as in implant-related infections, form complex structures in which they are enmeshed in an antiphagocytic polysaccharide matrix, the whole being known as a biofilm. Their growth state alters within this, ren dering them phenotypically resistant to almost all antibiotics. They may even be able to persist in metabolically inactive forms called small-colony variants: these can exist within cells and are also re sistant to many antibiotics that would otherwise kill wild-type organisms. If periosteum has been stripped and remains viable, it produces new bone called the involucrum. This may develop circumferen tially, producing a shell of living bone around the dead segment, thus preserving mechanical strength. Defects in the involucrum, through which sinuses communicate with sequestra, are called cloacae. Variations on this theme occur when flat bones or those of the spine are involved in haematogenous infection. In discitis and vertebral osteomyelitis, infection of the disc space is rapidly fol lowed by involvement of the two adjacent vertebral bodies. The infection may arrest as disc material is replaced by granulation tissue, eventually leading to fusion of the two involved vertebral bodies. In flat bones such as the pelvis or the skull, infection can spread

very rapidly in the cancellous bone between the two tables before exciting a periosteal reaction. The inside-to-out nature of haematogenous osteomyelitis is in contrast to the outside-to-in nature of contiguous focus osteo myelitis. In this case, periosteum is destroyed as part of the same process that has destroyed the overlying soft tissues. Cortical bone is killed and infection can enter the medullary cavity, thereafter extending as for haematogenous disease. Sequestra may separate and be discharged, but the adverse biological factors that led to the initial soft tissue loss may impair subsequent healing and permit further bone infection to occur. In this scenario, the compromise in the surrounding soft tissues will make infection persistence more likely and makes cure with antibiotics alone less likely. Epidemiology Classical acute haematogenous osteomyelitis has its peak incidence in childhood. Men are more commonly affected than women. In children, a greater incidence in the southern hemisphere and among certain racial groups (e.g. aboriginal Australians) has been described, with rates varying from 10 to 100:100 000/year. Socioeconomic Acute Time D E A B J I H C Chronic Infected Dead F G Intramedullary infection Cortical and periosteal extension Intramedullary and subperiosteal abscesses Periosteal stripping Bone death Sequestrum formation Sinus formation Involucrum formation Bone fragmentation Discharge of sequestra A B C D F G H G J E. F H G Acute Chronic D E E E. F I Fig. 20.3.2 Schematic diagram showing the evolution from acute to chronic osteomyelitis, with progressive necrosis, sequestration, and sinus formation.

20.3 Osteomyelitis 4691 factors may contribute to this variation. Acute osteomyelitis is also seen as a complication of infections of fractures and trauma, com monly seen in victims of military conflict and road traffic accidents or after orthopaedic instrumentation. Most acute bone infections now arise through these routes. Chronic osteomyelitis is such a diverse disease that an overall incidence and prevalence rate is not available, but incidence rises with age due to numerous causes including diabetes, peripheral vas cular disease, infirmity, and ulceration. Chronic osteomyelitis also results whenever acute osteomyelitis is not treated successfully. The global diabetes pandemic is particularly noteworthy, with an esti mated 252 million people affected in 2007, leading to a huge burden of chronic osteomyelitis of foot bones complicating diabetic neuro pathic ulceration. Prevention and control There are no proven means of preventing haematogenous osteo myelitis, but prompt treatment can prevent chronicity. Contiguous osteomyelitis can be prevented by the appropriate management of open fractures and of infective foci or chronic wounds whenever these are close to a bone or joint. Pressure-area care for immobile patients and appropriate foot care for people with diabetes can pre vent ulceration and subsequent osteomyelitis. Clinical features Acute osteomyelitis presents as rapid onset of pain and loss of func tion in the affected limb, usually accompanied by high fever and mal aise. It predominantly affects the metaphyses adjacent to the large weight-bearing joints, but any bone can be involved. Prostration, sweating, rigors, and vomiting from bacteraemia, which accompany 50% of cases, may also be present. In neonates and infants, an acute septic arthritis can be an early complication or a presenting feature of an acute osteomyelitis. In some joints, the capsule encloses not only the joint but also the metaphyseal growth plate, so infection may track out from the bone into the joint cavity. In older children, the joint capsule is much tougher and inserts at the growth plate. In both age groups, the cartilage of the growth plate forms a barrier to the direct passage of infection from the metaphysis to the epiphysis and the joint. Chronic osteomyelitis presents more variably, often in a sys temically well patient. Pain is the rule, unless there is underlying neuropathy, and there may be severe disability in the context of an ununited fracture or when the spine is involved. Wound or sinus tract drainage is usually present when osteomyelitis complicates ul ceration,

instrumentation, or other surgery. Bone may be visible or located with a sterile metal probe in the base of an ulcer or sinus. There may be evidence of soft tissue swelling or induration and bony tenderness on palpation or percussion. Some patients experience re peated flares of fever and acute illness due to inadequate drainage of deep pus or rapid extension into previously uninvolved soft tissue or bone. Minor ill health is common, manifesting as loss of weight or appetite, general malaise, or poor glycaemic control in people with diabetes. This is often only noticeable in retrospect when infection has been treated. Patients with vertebral osteomyelitis may present with bacter aemia and acute back pain (raising the possibility of spinal epidural abscess and the need for urgent diagnosis and treatment), but more often they present with chronic back pain and nonspecific illness. Differential diagnoses of degenerative back pain, osteoporotic frac ture, metastatic disease, and myeloma should be considered. The presence of severe back pain at rest, or of night pain, should prompt consideration of the diagnosis. Pain is often of a deep and unre mitting character that patients can distinguish from previous back pains. Spinal tenderness is an unreliable sign. Deformity and the de velopment of neurological signs are late features suggestive of loss of mechanical stability or the formation of paraspinal or epidural collections or masses. Osteomyelitis in the diabetic foot presents with overlying chronic ulceration. The location of the infection is linked to the biomechan ical changes produced by neuropathy that cause ulcers in high pres sure areas related to metatarsal heads, phalanges, interphalangeal joints, or—more rarely—the calcaneum or plantar area. Special forms of osteomyelitis include Brodie’s abscess; a well- defined chronic abscess in bone with a very indolent presentation. Chronic multifocal osteomyelitis presents in young people with a relapsing course and pain in several bones. It may be associated with SAPHO syndrome. Radiologically it mimics osteomyelitis of bac terial origin but is always culture-negative and is now thought to be a nonbacterial form of inflammatory osteitis. Differential diagnosis Primary or metastatic tumours or fractures may mimic acute or chronic infection. Charcot’s neuro-osteoarthropathy can be dif ficult to distinguish from infection in patients with underlying neuropathy, a problem that is very common in diabetic foot osteo myelitis.
A chronic periosteal reaction can arise from many causes, but commonly in the lower leg due to chronic venous insufficiency. While a periosteal reaction in this situation is common, osteomye litis is rare and is usually evident from other features such as massive soft tissue loss with obvious exposure of bone. Clinical investigation The white-cell count, erythrocyte sedimentation rate, and C-reactive protein, although generally elevated in acute infection and flares of chronic disease, are nonspecific and occasionally normal in chronic disease. It is helpful to see elevated inflammatory markers fall after treatment, but this may take several weeks. The alkaline phosphatase level is of no value, being neither sensitive nor specific for bone in fection. Blood cultures are essential in acute infection, when they may be the only means of obtaining a microbiological diagnosis. Serological tests are useful for the diagnosis of syphilis, yaws, bru cellosis, and occasionally bartonellosis. Plain radiography of chronic osteomyelitis typically shows patchy osteopenia or frank bone destruction, loss of definition of the cortex, areas of sclerosis, or periosteal reaction with new bone formation. These changes take many weeks to develop fully. In acute infection, the earliest change visible on plain radiography is soft tissue swelling (minimum 2–3 days), which is followed by periosteal reaction

 (7 days) and (lastly) bone destruction (10 days). If radiographs are abnormal, the changes need to be distinguished from those of tu mour, trauma, or degenerative bone disease. Repeat imaging at an interval (2–4 weeks) can sometimes help as untreated osteomyelitis is usually an aggressive process with rapidly evolving radiology. For more

rapid clarification of diagnosis, however, specialized imaging is needed. Ultrasound can identify subperiosteal collections and soft tissue abscesses and can demonstrate sinuses. Computed tomography (CT) scanning may be able to identify cortical erosion that has been missed on plain films and can demonstrate sequestra within bone. Reformatted images make it possible to produce sagittal or coronal images (e.g. to view vertebral body endplates and the spinal canal in patients unable to undergo MRI scanning) and three-dimensional images for surgical planning. Soft tissue collections are easily iden tified. Other than a lack of sensitivity early in the disease, the prin cipal pitfalls of CT scanning are the radiation dose, its lack of ability to determine the extent or activity of infection, and its sensitivity to image degradation from orthopaedic metalware. Isotope bone scanning is widely used, but there is a lack of con sensus on the utility of various tests. Conventional, three-phase, technetium bone scans are sensitive but nonspecific. Specificity may be increased by the addition of labelled leucocyte scanning. Other reagents include labelled immunoglobulins, antileucocyte mono clonal antibodies, and even radiolabelled antibiotics. Most nuclear scans are unhelpful in the presence of recent injury or fracture. MRI is the standard and best method for diagnostic imaging of osteomyelitis (Figs. 20.3.3 and 20.3.4). It can detect intra and extraosseous oedema, abscesses, dead bone fragments, and sinus tracts. It can distinguish active from inactive infection. MRI has the advantages that it is noninvasive and is becoming more widely avail able. It must be interpreted with care and expertise. Acute infections will have extensive oedema in the bone and soft tissues which may simply be inflammatory reaction, rather than active infection. Also, the scan images can be degraded by metal implants or even micro scopic metal debris from previous implants or surgery. MRI is not good for monitoring response to therapy after treatment, as bone changes may persist on scans for many months. Newer imaging modalities with SPECT-CT (single-photon emission computed tomography with CT) and FDG-PET/CT (positron-emission tomography with CT) allow an assessment of the physiological changes around bone infections combined with the localizing ability of CT. When these scans are negative, they give a high degree of certainty that there is not an active infection. Positive scans are helpful in planning surgery. The microbiological standard for the diagnosis of osteomyelitis is the growth of bacteria from samples of bone, taken with precautions to prevent contamination from superficial flora. Pus or soft tissue associated with infected bone may be acceptable, but sinus tract or wound swab cultures are not. The bacteria isolated from wounds are poorly predictive of the deep flora because of asymptomatic colonization. Cultures of this kind should be reserved for detecting multiresistant organisms (such as meticillin-resistant S. aureus (MRSA)) for infection control purposes only. Fluid for microscopy and culture can be aspirated, under aseptic conditions, from periosteal or subperiosteal abscesses. In infants, (a) (b) Fig. 20.3.3 Acute osteomyelitis of the femur in a child. (a) The plain radiograph, after one day of illness, is normal. S. aureus was isolated from blood cultures. (b) MRI scan (short T1 inversion recovery sequence) of the same patient on day two. There is marked soft tissue and intraosseous oedema (high signal). Subperiosteal abscesses can clearly be seen as linear areas of high signal just outside the cortex, tracking proximally up the femur from the metaphysis.

20.3 Osteomyelitis 4693 needle aspiration of bone itself is safe and well tolerated if per formed by someone experienced in the technique. Bone biopsy can be performed surgically or percutaneously (by needle biopsy). In neuropathic ulcers, bone can be obtained by curettage following debridement of the overlying ulcer material. The laboratory must be made aware of the importance and nature of any specimen sent so that it can be appropriately processed and interpreted. As epidemiologically appropriate, cultures for mycobacteria, brucellae, and fungi may need to be

requested. When implants are removed at surgery for possible infection, they can be sent for sonication. This technique disrupts biofilm adherent to the implant and may allow culture of bacteria which are difficult to grow in standard culture methods. Bone histology is also an important diagnostic test: the presence of inflammatory cells, dead bone, and active bone remodelling are hallmarks of infection. They may provide the only confirmation of infection in cases where the culture results are unhelpful and may suggest specific pathogens if the changes are granulomatous rather than pyogenic. Criteria for diagnosis Formal criteria, as defined for endocarditis and many inflamma tory disorders, have not been agreed by consensus. The criterion standard is considered to be the culture of bacteria from reliably obtained samples of bone, accompanied by histological evidence of inflammation. However, these criteria can be difficult to satisfy in many cases, so it is common to make a clinical diagnosis based on a range of clinical and imaging features. Treatment Acute osteomyelitis Acute osteomyelitis is an orthopaedic and a medical emergency that may respond to antibiotics alone, with good outcomes if treated be fore the onset of bone death or abscess formation. Treatment should be initiated on the basis of the clinical diagnosis, with investigations used to confirm the diagnosis once treatment has begun. Following blood cultures, high-dose intravenous antibiotics effective against S. aureus, β-haemolytic streptococci, and—in some situations— aerobic Gram-negative rods, should be given. Appropriate regi mens include a cephalosporin, a β-lactam/β-lactamase combination (amoxicillin/clavulanate or ampicillin/sulbactam), or the combin ation of an antistaphylococcal penicillin and gentamicin. Vancomycin or an alternative will be necessary if the patient has risk factors for infection with MRSA. Antibiotics can be modified based on culture results. For patient comfort, the limb should be splinted and ele vated, and analgesia should be given. Surgery is indicated if abscesses are present or if the patient is failing to respond to medical measures. Abscesses must be drained and, although controversial, drilling of the bone allows free drainage of contained pus. In acute infection, the surgeon aims to minimize damage to living bone and soft tissues and thereby avoid further devascularization and consequent excessive bone death. Surgery is mandatory if there is extension of an acute osteomyelitis to a joint. The necessary duration of antibiotic therapy is unclear, but treat ment for less than four weeks is associated with higher rates of re lapse. In children, oral therapy can be considered when all of the following criteria are met: (1) the patient is afebrile after the initial (a) (b) (c) Fig. 20.3.4 (a) A plain radiograph showing chronic osteomyelitis of the distal tibia in an adult, following a fracture. There is central bone lysis with patchy sclerosis and (b) MRI of the same patient showing the central medullary abscess, overlying soft tissue oedema, and periosteal reaction on the lateral side. The screw in the lower part of the tibia has caused distortion of the magnetic resonance image. The transverse scan (c), shows the central sequestrum, surrounded by pus. There is erosion of the medial cortex of the tibia and extensive soft tissue inflammation.

 48–72 h of intravenous treatment; (2) there is no evidence of ab scess formation, metastatic infection, or bacteraemia; (3) there is no suspicion from the history or imaging that, prior to treatment, in fection has been prolonged or is associated with dead bone; (4) the organism is sensitive to reliably bioavailable oral antibiotics; and (5) compliance with therapy can be assured. Less information is available for adults. The lower rates of bone blood flow and turnover make the revascularization and absorp tion of necrotic bone and the delivery of antibiotics and white cells less certain. Also, adults with acute infection tend to have multiple co-morbidities which may interfere with antimicrobial therapy. Adult acute osteomyelitis may be treated with intravenous therapy for periods of at least four weeks (outpatient parenteral antibiotic

therapy (OPAT) programmes are useful for this), but certain drugs, notably clindamycin and ciprofloxacin, are highly bioavailable and have proved useful in the oral treatment of osteomyelitis. A recent sys tematic review and meta-analysis of five randomised controlled trials and 10 observational studies of short- versus long-course (4-6 weeks) antibiotics concluded that a long course was to be preferred in verte bral osteomyelitis, especially in patients with S. aureus infection. Chronic osteomyelitis To achieve long-term arrest of infection, the management of chronic osteomyelitis usually requires multiple, coordinated inputs. The out come of treatment is dependent on the extent of the infection and also the health of the host. Attention to nutrition, smoking cessation, diabetes management, and other co-morbidities is important before beginning complex treatment. The aims of treatment are outlined in Box 20.3.1. Surgery Detailed consideration of surgical methods is beyond the scope of this book, but the importance of an expert surgical opinion in managing chronic osteomyelitis cannot be overstated, even if the conclusion of that input is that a surgical approach is not technically possible or in the patient's overall interests. Recent major surgical advances include the use of free-tissue transfer and bone transport techniques to close very large bony and soft tissue defects. These permit much more radical approaches to the resection of diseased and dead tissues. In this way, surgery can potentially convert chronic infected wounds with dead bone and soft tissue into contaminated wounds of living bone with healthy soft tissue cover. This allows a re duction in the duration of antibiotic therapy in some situations and offers a greater range of patients the possibility of long-term arrest of infection. In certain circumstances, surgery is not the first choice of treat ment, even in chronic disease (Box 20.3.2). Antibiotics These play an important role after surgery, although the 'added value' they confer is uncertain and may depend on the extent of surgical re section. If a full segment of the bone has been removed, including all of the infected bone, a shorter antibiotic course may be appropriate of up to two weeks. Antibiotics may also help when the patient refuses surgery, when there is no clearly definable surgical target, or when the risks and consequences of surgical resection would be worse than the disease itself. The choice of antibiotics should be guided by the culture results. Intravenous therapy may need to be prolonged (for up to six weeks) where there is thought to be a risk of unreliable compliance, poor absorption, or lack of efficacy of oral therapy. OPAT programmes are valuable for shortening the hospital stay for such patients. Periods of total antibiotic treatment vary from weeks to many months, but there is a growing trend to shorten the duration of treatment when an expert surgeon has achieved a radical surgical clearance, pro vided that local and systemic host factors are favourable. Antibiotics can also be delivered locally, by implanting antibiotic-loaded bone cement at the time of surgery. More recently absorbable antibiotic carriers have been investigated (Calcium Sulphate pellets with aminoglycosides and biocomposites with hydroxyapatite) which can deliver very high doses of antibiotic into bones and then dissolve over weeks or months, to be replaced by living bone. The relative efficacies of intravenous, oral, or local antibiotics have received little attention and treatment protocols vary widely. Adjunctive treatment It is important to assess for, and if possible control, factors that may affect wound and bone healing. These include ischaemia due to peripheral vascular disease, anaemia, diabetes, hypoxia from respiratory or cardiac failure, peripheral oedema, poor nutrition, and smoking. Where neuropathy has contributed to ulceration, ap propriate pressure relief is essential for healing and for secondary prevention. This must be continued indefinitely through the provi sion of specialist footwear, cushions, or beds. The patient must be Box 20.3.1 Chronic osteomyelitis—aims of treatment Preoperative Patient assessment and optimization of health Full discussion of treatment options, including amputation or no treatment Stop antibiotic therapy if possible Intraoperative Harvest of uncontaminated, representative

samples Removal of dead bone and soft tissues Bone stabilization Elimination of cavities in bones (dead spaces) Restoration of healthy soft tissue cover over the bone Postoperative Begin appropriate initial antimicrobial therapy Functional rehabilitation Continued, culture-specific antimicrobial therapy Monitoring for early recurrence of infection or complications Second stage bone or joint reconstruction Box 20.3.2 Surgery may not be the first choice of treatment Discitis and vertebral osteomyelitis Surgery is reserved for abscess formation, progressive pain or deformity, instability, spinal cord compression, or persistent sepsis Tuberculous osteomyelitis Surgery is reserved for mechanical complications, pain, or persistent infection Patients with diabetic foot osteomyelitis Some authorities quote that chronic osteomyelitis can be arrested in about 70% or 80% of cases with limited podiatric debridement of bone.

20.3 Osteomyelitis 4695 taught about neuropathy and trained in methods to prevent further ulceration. Hyperbaric oxygen therapy has been widely employed with anecdotal success, but its effectiveness and its precise role are unclear, with definitive randomized trials still awaited. Given its expense, establishing a clear evidence base for hyperbaric oxygen should be a prerequisite for its commissioning and use. Prognosis More than 90% of cases of acute osteomyelitis that are amenable to medical treatment can be arrested. Chronic osteomyelitis can be ar rested in about 80% or 90% of cases, usually when expert surgery has been combined with antibiotic treatment. Recurrence is most common within the first year, but may occur at any time, and recur rences have been described over 50 years after an initial infection has apparently been treated successfully. This poses major difficulties for the design of clinical trials, as extended follow-up is needed to make definitive statements about success or failure. Long-standing active chronic osteomyelitis may be associated with the eventual develop ment of squamous metaplasia or carcinoma in a sinus and with the deposition of amyloid, but both these events are rarities, albeit im portant to consider. Pathological fracture can occur with or without treatment and affects 4–8% of patients. Occupational, quality of life, and psychosocial aspects Pain, chronic sepsis, and physical disability have a significant im pact on quality of life. Psychological well-being is further affected by issues common to all chronic diseases, together with anxiety and de pression over risks of death, paralysis (e.g. in spinal infection), and limb loss. The stigmatizing effects of chronic discharging wounds, and feelings of anger or failure where infection has resulted from an accident or surgery can cause social isolation. The multidisciplinary team caring for the patient must have awareness and experience of dealing with these issues and access to appropriate rehabilitation re sources to optimize long-term function and quality of life. Likely developments in the near future The rise in antimicrobial resistance is likely to make the antibiotic treatment of osteomyelitis more challenging and require the use of new agents, notably against multiresistant strains. The delivery of antibiotics locally into bones is attractive as it reduces systemic side effects and removes concerns about compliance with therapy. A major worldwide drive to decrease healthcare-associated infec tions may bear fruit but be offset by increasing numbers of patients being injured through conflict or the effects of climate change. The development of clear guidance on the management of open fractures has the potential to reduce the high rates of post-trauma osteomyelitis seen in high energy injuries. The ageing populations of the industrialized world and the rising prevalence of diabetes are likely to result in further increases in the burden of diabetic foot and pressure sore osteomyelitis. For those able to afford them, there may be balancing advances in diagnosis using the polymerase chain reaction to detect microbial nucleic acid, microarrays to de tect infection-specific host responses, and improved surgical re constructive methods. FURTHER READING Berendt T, Byren I (2004). Bone and joint infection. Clin Med, 4, 510–18. Bose D, et al. (2015). Management of infected

nonunion of the long bones by a multidisciplinary team. Bone Joint J, 97-B, 814–7. Chihara S, Segreti J (2010). Osteomyelitis. Dis Mon, 56, 5–31. Cierny G, DiPasquale D (2006). Treatment of chronic infection. J Am Acad Orthop Surg, 14, S105–110. Conterno LO, da Silva Filho CR (2009). Antibiotics for treating chronic osteomyelitis in adults. Cochrane Database Syst Rev, 8, CD004439. Govaert, GA, et al. (2017). Accuracy of diagnostic imaging modalities for peripheral post-traumatic osteomyelitis – a systematic review of the recent literature. Eur J Nucl Med Mol Imaging, 44:1393–1407. Gristina A, et al. (1985). Adherent bacterial colonisation in the patho genesis of osteomyelitis. Science, 228, 990–3. Huang CY, et al. (2019). Short- versus long-course antibiotics in osteo myelitis: a systematic review and meta-analysis. Int J Antimicrob Agents, 53, 246–60. Klenerman L (2007). A history of osteomyelitis from the Journal of Bone and Joint Surgery: 1948 to 2006. J Bone Joint Surg Br, 89, 667–70. Lew DP, Waldvogel FA (2004). Osteomyelitis. Lancet, 364, 369–79. McNally MA, Nagarajah K (2010). Osteomyelitis. Orthopaedics and Trauma, 24, 416–29. McNally MA, Sendi P (2015). Implant-associated osteomyelitis of long bones. In: Zimmerli W (ed) Bone and joint infections: from microbi- ology to diagnostics and treatment, pp. 303–23. John Wiley & Sons, Chichester. McNally MA, et al. (2016). Single-stage treatment of chronic osteo myelitis with a new absorbable, gentamicin-loaded, calcium sul phate/hydroxyapatite biocomposite. Bone Joint J, 96-B: 1289–1296. Miller AO, Henry M (2009). Update in diagnosis and treatment of dia betic foot infections. Phys Med Rehabil Clin N Am, 20, 61–25. Rega EA, Brochu CA (2001). Paleopathology of a mature Tyrannosaurus rex. J Vert Paleontol, 21, 92A. Sconfienza LM, et al. (2019). Diagnosis of peripheral bone and pros thetic joint infections: overview on the consensus documents by EANM, EBJIS, and ESR (with ESCMID endorsement). Eur Radiol, doi: 10.1007/s00330-019-06326-1. Sendi P, Zimmerli W (2012). Antimicrobial treatment concepts for orthopaedic device-related infections. Clin Microbiol Infect, 18, 1176–84. Sheehy SH, et al. (2010). The microbiology of chronic osteomyelitis: prevalence of resistance to common empirical anti-microbial regi mens. J Infect, 60, 338–43. Street TL, et al. (2017) Molecular diagnosis of orthopaedic device in fection direct from sonication fluid by metagenomic sequencing.
J Clin Microbiol, 55: 2334–2347. Walenkamp GHIM, (1997). Chronic osteomyelitis; How I do it. Acta Orthop Scand, 68(5): 497–506.

Revision #1
Created 2026-01-22 16:41:07 UTC by Omar Ayman
Updated 2026-01-22 16:41:07 UTC by Omar Ayman