43 Infection of the bones and joints

ACKNOWLEDGEMENTS

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Antibiotic therapy

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Patients with septic shock, or with rapidly advancing local or systemic signs of infection, should receive prompt empiric antibiotic therapy . When delay in antibiotics would be unsafe, blood cultures, local aspiration of pus or radiologically guided biopsy may give valuable culture material immediately prior to starting antibiotics. In most cases, it is safe to delay antibiotics until definitive operative microbiological samples have been taken, particu - larly in chronic or implant-related infections. For patients who should be made; if safe to do so, antibiotics should be stopped at least 2 weeks before biopsy or surgery . Local guidelines should be followed, but most hospitals rec ommend a ‘community-acquired’ level of cover using an agent such as co-amoxiclav . Additional antibiotics to cover resistant Gram-positive organisms (e.g. vancomycin for methicillin resistant S. aureus [MRSA]) are considered if there has been significant prior hospital exposure or if the patient is known to be colonised with these organisms. Cover for resistant Gram-negative organisms (e.g. meropenem for Pseudomonas considered in certain settings, including severe diabetic foot infection. In the past, prolonged intravenous antibiotic courses (i.e. 4–6 weeks of treatment) were often recommended. The recent OVIV A trial has shown that oral therapy is equally e ﬀ ective, providing tha t the organism(s) is susceptible and the patient can tolerate the chosen antibiotic. Summary box 43.4 Antibiotics for osteomyelitis /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF

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Clinical features

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Most patients present after an acute or subacute history with a single hot, swollen, painful joint. In children, there is often a history of recent minor trauma. The joint is held immobile in the ‘position of comfort’, with ‘pseudoparalysis’ in neonates. Sidney Ringer , 1835–1910, Professor of Clinical Medicine, University College Hospital, London, UK. /uni25CF /uni25CF - /uni25CF /uni25CF /uni25CF - /uni25CF /uni25CF) is There is severe pain if any attempt is made to move the a ﬀ ected joint actively or passively . In children and adults, the knee joint is most frequently a ﬀ ected, whereas in neonates it is the hip. Fever and other systemic signs are usually present, but their absence does not rule out the diagnosis. Fever is absent in about one-third of cases.

Extremes of age Underlying joint abnormality, especially rheumatoid arthritis Immunocompromise (e.g. diabetes mellitus, HIV infection, immunosuppressive therapy) Joint instrumentation (e.g. steroid injection, arthroscopy) Intravenous drug abuse Indwelling central venous catheter Bacteraemia (especially Staphylococcus aureus) HIV, human immunode /f_i ciency virus.

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PJIs may present early (within 3 months of surgery), in a delayed manner (3–24 months from surgery) or late (after 2 /uni00A0 years). /uni25CF Early infections are acquired at surgery and are usually caused by virulent organisms (e.g. S. aureus). They present with a discharging wound, cellulitis, pain, inflammation and swelling. /uni25CF Delayed infections are more characteristically due to low-virulence organisms (e.g. coagulase-negative staphylo cocci or cutibacteria). André Gächter , contemporary , Swiss orthopaedic surgeon. . The - /uni25CF Late infections are more likely to present with an indo - lent clinical syndrome of joint discomfort or mechanical dysfunction (‘start-up’ symptoms are particularly charac - teristic), with or without a discharging sinus. Late presen - tations are usually due to haematogenous infection of a pre viously uninfected joint, from bacteraemia. The source may indicate the microbiology (e.g. pneumococci from re - spiratory origin, Salmonella spp. from the gut, Escherichia coli from the urinary tract).

(b) Figure 43.4 (a) Septic arthritis of the hip in a person who injects drugs. This was untreated for several weeks, resulting in destruction of the joint surface. (b) The same hip after 9 months without treatment. The proximal femur and acetabulum have been grossly eroded by infection.

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The global prevalence of diabetes has increased exponentially in recent years. Foot infections are a leading cause of hospital admissions in this group, with an annual incidence of foot complications of 1–2% per year owing to the combined influ - ence of macro- and microvascular insu ffi ciency , mechanical disruption, peripheral and autonomic neuropathy , immune defects and impaired tissue healing. Ulceration of the calca - neum and bones of the foref oot is common (Figure 43.11) and will result in amputation in up to one-fifth of cases. Infection begins as invasion of bacteria into the com - promised tissues and will rapidly spread to deep structures. Diagnosis is made on the clinical signs and symptoms of local inflammation and systemic upset. The presence of a wound/ ulcer, spreading cellulitis, fevers or critical ischaemia indicate a e infection and the need for urgent treatment. more sever Blood tests are frequently unhelpful, as inflammatory mark - ers may be normal or only mildly raised. Plain radiographs may show evidence of osteomyelitis but can be normal (par - ticularly ear ly in infection). MRI is the most sensitive imaging modality for diagnosis of bone involvement. Superficial swabs - - - terials -

The Figure 43.11 A severe diabetic foot infection, with marked infection, necrosis and tissue loss. The patient was neuropathic and had ankle and hindfoot deformity. The foot was salvaged with a corrective triple fusion of the hindfoot, excision of the infected ulcer, antibiotic therapy and primary closure of the lateral soft tissues.

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The most important risk factor for osteomyelitis is the presence of a foot ulcer Ulcer swabs are not reliable in determining the pathogens responsible for osteomyelitis Bone biopsy for culture should be considered in extensive/ complex infection but may not be necessary in mild disease In severe disease, surgical debridement of collections and/ or necrotic tissue is required, followed by antibiotics tailored according to culture results

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Diagnosis

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Clinical - Diagnosis is predominantly clinical with confirmation using other tests, as outlined below . Biomarkers Raised inflammatory markers (erythrocyte sedimentation rate [ESR], C-reactive protein [CRP] and white cell count [WCC]) are characteristic of acute infection, but they are neither su ﬃ ciently sensitive nor su ﬃ ciently specific to rule infection in or out. Recently , new synovial fluid markers (α -defensin and calprotectin) have shown high accuracy in diagnosis of PJI. Imaging Plain radiographs can demonstrate dead bone, periosteal reaction, involucrum formation and loosening of implants. However, they are often normal in the first few days of infec - tion. A normal radiograph does not exclude infection. Over time, radiographs will show progressive implant loosening, bone lysis or sequestration in chronic osteomyelitis. Ultrasonography is ideal for identifying soft-tissue collec - tions and joint e ﬀ usions and can be used to guide bone biopsy and aspiration. Computed tomography (CT) scans are helpful in assessing bone union of infected fractures. Small sequestra and cortical erosions are best seen with CT and these scans can be used to plan surgery for excision of dead bone (Figure 43.3a). Isotope bone scans are of very limited value as they are non-specific and give no information that may guide diagno 18 sis or treatment. The combination of F-fluorodeoxyglucose 18 positron emission tomography (FDG-PET) with a CT scan allows localisation of active infection in chronic osteomyelitis 18 and may facilitate planning of surgery . FDG-PET/CT is not specific to infection and so cannot reliably distinguish infective from aseptic loosening around implants. Magnetic resonance imaging (MRI) scanning is the investi gation of choice, in the absence of metal implants. It is highly sensitive and specific, showing all components of the disease (Figure 43.3b). However, it can overestimate the extent of infection when ther e is widespread reactive oedema. α β Microbiological diagnosis Good treatment starts with a reliable microbiological diagno - sis. Superficial swabs from wounds or spontaneously draining - pus are unreliable. Cultures from these do not reflect the pathogens in the bone. Microbiological samples may be falsely negative if antibiotics are given first. Synovial tissue samples are particularly important in producing a higher diagnostic yield for infection with mycobacteria or fungi. In chronic infections, particularly those involving pros - thetic material, multiple biopsy samples are needed. It is rec - - ommended to take at least five tissue samples; each one with a separate, sterile instrument. Samples should be promptly transferred to the laboratory with clinical details of the infec - tion. Cultur e should be maintained for at least 10 days in mus - culoskeletal infections to allow identification of slow-growing

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Bone and joint infections from haematogenous spread remain common worldwide The increased use of implants for joint replacement and fracture /f_i xation are an important source of new infections Immunocompromised patients are another increasing source (e.g. diabetes, cancer treatment)

FRACTURE-RELATED INFECTION

FRACTURE-RELATED INFECTION

Infection complicates around 3–5% of all fracture fixations. Open tibia fractures are a high-risk group with up to 25% becoming infected after fixation. Calcaneal fractures and ankle fracture fixation in the elderly also have high infection rates. Many of the principles outlined above for PJI can be applied to infections associated with metalwork used to fix fractures. There are several clinical scenarios which must be addressed: /uni25CF Unhealed fracture with stable fixation . This is usually seen early after fixation and can be managed with deep sampling, debridement of infected tissues and man agement of dead spaces (often with local antibiotic carriers) (‘DAIR’ approach). It is extremely important to provide good soft-tissue cover over the fracture. In the tibia, this will most often require a plastic surgical reconstruction. After debridement, systemic antibiotics must be given to suppress infection until bone union. /uni25CF Healed fracture with infected implant . In these cases, the implant can be removed, but there should still be a careful debridement, deep sampling, dead space man agement and soft-tissue cover. /uni25CF Unhealed fracture with unstable fixation bility is essential for bone healing and eradication of in fection. If the implant is not stable, it should be removed and replaced by an external fixator. Radical excision of the infected fracture is needed and the resulting defect may present a major reconstructive c hallenge (Figure 43.7 Recently , antibiotic-coated locking nails have been used to restabilise infected fractures with some success. FRACTURE-RELATED INFECTION

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FURTHER READING

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Bone infection has all the elements of any inflammatory condi tion but bone produces some specific pathological features. Acute osteomyelitis occurs when pathogenic organisms cause infection, leading to inflammation in the bone and surround ing tissues. The medullary bone may form abscesses and pus ma y track through the cortex to form periosteal elevation and soft-tissue extension. This process will devascularise the cortical bone, causing bone death – the characteristic featur of chronic osteomyelitis. Bacteria can adhere to dead bone or implant surfaces, forming a complex community enveloped in a polysaccha ride matrix, known as a biofilm. These bacteria alter their metabolic state, making them mor e resistant both to the host immune system and to antibiotics. Toxins and lytic enzymes ly damage to articular cartilage. from bacteria cause ear Hans Christian Joachim Gram , 1853–1938, Professor of Medicine, Copenhagen, Denmark. dead fragments of bone (sequestration) and forming sinuses to drain pus and discharge small bone fragments. New bone is laid down around the infection from the periosteum (involu - crum) (Figure 43.2). In septic arthritis, infection may follow direct ingress of bacteria after injury or surgery , or may result from discharge of an adjacent acute osteom yelitis into the joint. Particularly in neonates or the elderly , bacteraemia may infect a previously normal joint. Summary box 43.2 Pathology of bone infection /uni25CF /uni25CF /uni25CF

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Introduction

INTRODUCTION

Osteomyelitis is an old disease, identified in dinosaur bones, early hominids and skeletons from ancient civilisations. It is named from the components of the disease (osteo , bone; marrow; itis , inflammation; Greek) and is caused by bacterial invasion of the bone. Worldwide, acute infection of bones and joints remains common in children. In adults, open fractures and orthopaedic implant surgery produce a large number of severe infections each year. Orthopaedic infection can present acutely , with major sys temic upset, local inflammation and purulence, or insidiously , with gradual bone destruction leading to loss of function and slowly evolving local symptoms, with or without systemic fea tures. Bone and joint infections cause a substantial burden of complex morbidity . Acute infections can be life- or limb-threat ening, w hile chronic disease may produce pr olonged disability , pain and ill-health. This has major implications for patient mental health and social interactions.

Learning objectives

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To understand: Characteristic features of septic arthritis, acute and • chronic osteomyelitis and implant infections Diagnostic principles in bone and joint infection • Learning objectives

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MUSCULOSKELETAL INFECTION CAUSED BY MYCOBACTERIA

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Tuberculous arthritis/osteomyelitis remains prevalent in low- and middle-income countries. There is now a resur gence across the world as a consequence of migration and immunocompromise (including human immunodeficiency tuberculosis . Around half of all cases a ff ect the spine, typically - manifesting as para-discal infection but also causing discitis and vertebral osteomyelitis. Native joint infection typically presents with monoarticular pain in a weight-bearing joint. For optimal management of tuberculosis, the patient must be referred to a specialist multidisciplinary team for input that includes the following components. /uni25CF Baseline screening for HIV and other blood-borne viruses. /uni25CF Assessment for other sites of mycobacterial infection. /uni25CF Measurement of baseline renal and liver function, to be repeated at intervals throughout treatment. Drug-induced hepatitis is the commonest serious side e ff ect that may re - quire temporary withdrawal or alteration of therapy . /uni25CF Baseline and follow-up testing of hearing (if injectable agents to be used) and colour vision (if ethambutol to be - used). /uni25CF Consideration of any potential drug interactions (rifampi - cin is a potent inducer of the cytochrome P450 system; it can interact with many classes of drug, including anticon - vulsants, antiretroviral therapy , anticoagulants, antibiotics and antifungals). /uni25CF Institution of appropriate infection control precautions - and contact tracing. /uni25CF Appropriate education and support to optimise adherence to therapy . /uni25CF Prescription of an appropriate combination of drug ther - apy . /uni25CF For fully sensitive M. tuberculosis , the preferred regimen is oral rifampicin, isoniazid, pyrazinamide and etham - butol for 2 months, followed by rifampicin and isonia - zid for a further 4 months. /uni25CF Worldwide, there is an increase in the prevalence of - drug-resistant tuberculosis, classified as multidrug re - sistant (MDR) and extensively drug resistant (XDR). Infection with these organisms requires a treatment regimen that includes an injectable agent (typically ami - kacin, kanamycin or capreomycin) together with oral agents selected according to the susceptibility profile of the isolate (these may include cycloserine, ethionamide, para-aminosalicylic acid [PAS], fluoroquinolones and linezolid). Prolongation of therapy is r equired, and side e ff ects/toxicity are common. /uni25CF Surgery is only recommended to decompress or stabilise the spine and occasionally to confirm the diagnosis by tis - sue biopsy . Non-tuberculous mycobacteria are ubiquitous environmen - tal organisms. They are best recognised as agents of disease in patients with underlying immunocompromise (including HIV , diabetes and organ transplantation) or other risk factors for introduction of infection (such as penetrating trauma or the presence of a pr osthesis). However, they may occasionally also cause infection in hosts without obvious risk factors. Treatment can be di ffi cult; these organisms are resistant to the standard agents used for first line antituberculous therapy; surgery to debride and drain sites of infection can therefore be - particularly important to reduce the bacterial burden. There is no single standardised drug regimen or duration, so choice of and length of treatment depends on the location of disease; extent of surgical debridement; the identification and pheno typic characteristics of the organism; and the patient’s underly ing condition, presence of immunocompromise and response to therapy . As for treatment of M. tuberculosis , expert medical oversight is crucial throughout treatment.

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Management

Management

Successful treatment requires accurate diagnosis and a multi - disciplinary approach to deliver a package of care, summarised as follows: /uni25CF Preoperative: /uni25CF patient assessment and clinical staging of disease; /uni25CF full discussion of all treatment options with potential complications; /uni25CF diagnostic tests for general health; /uni25CF optimisation of patients and treatment of comorbid - ities. /uni25CF Operative: /uni25CF exposure for multiple, deep bone sampling; /uni25CF excision of all a ff ected tissue; /uni25CF intravenous antibiotics after sampling; /uni25CF bone stabilisation, if necessary; /uni25CF dead-space management; /uni25CF soft-tissue cover, which may include plastic surgery . /uni25CF Postoperative: /uni25CF functional rehabilitation; /uni25CF continued antimicrobial therapy guided by culture re - sults, with regular clinical monitoring. - The principles listed above dictate that a range of surgical and medical specialists will be needed to treat patients with bone and joint infections. If the patient is systemically well, ved tions, optimise patient there is often time to complete investiga health and plan interventions. Complex infections should be referred early to centres that specialise in these cases. Atten - tion to diabetes control, peripheral vascular disease, nutrition and smoking cessation is essential. Many patients will benefit from psychological support or at least good counselling around the di ffi culties of eradicating infection and the components of treatment.

Mag

Management

Surgical management Medical treatment alone is rarely indicated in joint sepsis. Prompt surgical drainage is a priority to avoid further damage to the cartilage. Arthroscopic washout is commonly performed but it may be di ffi cult to remove loculated areas of infection. Washout should be with Ringer’s solution or of the risk of chondrolysis. There should be a low threshold for open arthrotomy , particularly if a joint is not settling. A synovectomy is recommended if there is major synovial thickening, aggressive synovitis or subchondral erosions seen on radiology (Gächter stages 3 and 4). Inadequate clearance may lead to chronic infection with destruction of the joint (Figure 43.4). Treatment may then require joint excision, joint fusion or staged joint replacement. Medical management Antibiotics are usually given for 3–6 weeks (beginning with intravenous therapy). There are sparse data to guide duration. Longer courses should be considered if the infection is slow to resolve, if more than one washout is required, if the patient is bacteraemic and/or if the infection is caused by S. aureus choice of antibiotics is as given in Summary box 43.4 . Summary box 43.6 Native joint septic arthritis /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF

Most common at extremes of age, in patients with rheumatoid arthritis and in association with immunocompromise Most commonly affects hips in neonates and knees in adults and children The commonest pathogen is S. aureus Joints should be aspirated for microbiology before starting antibiotics, if safe to do so Management is prompt surgical joint washout, followed by 3–6 weeks of antibiotics

Management

A multidisciplinary approach is required, including ortho paedics, plastic surgery , infectious diseases/microbiology , α pharmacy , nursing, occupational therapy and physiotherapy , centred on the patient’s understanding and wishes regarding their condition. Many patients have other medical comorbid - ities tha t should also be addressed and optimised. PJI can be - associated with a range of emotional, psychological and mental health issues, ranging from anger about surgical complications to depression arising from chronic symptoms, lack of function and prolonged hospitalisation. T he choice of surgical strategy for prosthetic joints can be categorised as: /uni25CF salvage of an infected implant; /uni25CF removal of the infected implant with or without reimplan - - tation.

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determine this (i.e. salvage for early infection versus removal and revision for late infection). Others regard any firmly fixed implant as potentially salvageable, irrespective of the timing (and there are now several studies showing that this is feasi ble). However, it is agreed that loose infected implants should always be removed (Figure 43.6). Furthermore, it is essential to achieve soft-tissue cover of bone and pr osthetic material. This may be di ffi cult around the knee, requiring local muscle flaps. Management options can be divided into the following broad approaches. /uni25CF Debridement, antibiotics and implant reten tion - ‘DAIR’ . This can only be undertaken if the pros thesis is well fixed. DAIR is not a form of washout as all infected soft tissue and necrotic bone must be fully excised and modular components exchanged. This cannot be achieved by arthroscopic surgery . Good soft-tissue cov is essential. Following debridement, the patient is treated with long-term antibiotics (frequently 6 weeks of intra venous therapy followed by 6 months or more of oral anti biotics). Prolonged infection-free intervals can be achieved in 80% of patients but success with this strategy may be lower in infections caused by S. aureus or with multiresis tant organisms. /uni25CF Two-stage joint revision surgery . A thorough ex cision is undertaken and all cement and loose foreign ma terial is removed. An antibiotic-impregnated spacer may be implanted (which may be articulating). This is a tem porary measure and cannot withstand full weight-bearing. The patient is treated with oral or intravenous antibiotics, Gathorne Robert Girdlestone , 1881–1950, Nu ffi eld Professor of Orthopaedics, University of Oxford, UK, described excision arthroplasty of the hip for septic arthritis. ed after the course of antibiotics has been completed. In recent years ther e has been a trend towards shorter inter - vals between stages, often within the 6-week antimicrobial - therapy . /uni25CF Single-stage joint revision surgery . The procedure is the same as above, but removal and reimplantation are undertaken in the same operating session. Healthy soft tissues around the new implant are essential to prevent reinfection. Some centres consider single-stage revisions when less florid signs of infection are present (i.e. absence of collections or sinus tracts), or for frail patients for whom - the risk of a second operation is higher. There are no ad - - equate trial data comparing outcomes with the two-stage approach. /uni25CF Joint removal or fusion . When reconstruction options are not technically possible or are ruled out by comorbid er conditions, removal of the prosthesis without reimplanta - tion may palliate symptoms. An example is the Girdlestone - excision arthroplasty of the hip. In prosthetic infections of - the knee, ankle or wrist, it may be possible to create a joint fusion after pr osthesis removal. This is complex surgery , which may involve major bone reconstruction. Amputa - - tion may be necessary for knee or ankle implants. /uni25CF Suppressive therapy with antibiotics . In patients - who are not medically fit for any operative intervention, or - who choose to decline all surgical options, long-term treat - ment with antibiotics may help to suppress the symptoms - of infection. There are limited data, but anecdotally the success rate of this approach is low .

(a) Figure 43.6 (a) Sinus draining from the scar over the lateral side of the hip. This patient had a total hip replacement 14 years before that had been complicated by a wound haematoma and infection. (b) Radiograph of both hips of same patient. Both hips are loose but only the right side has de /f_i nite infection (arrows). (b)

Prosthetic joint infection /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF

Well- /f_i xed prostheses may be Debrided, treated with Antibiotics and the Implant Retained (‘DAIR’ approach) Loose prostheses must be removed Replacement can be made at the initial surgery (one stage) or after a delay to allow infection to be eradicated with antibiotics (two stage) Multiple surgical samples are crucial for identifying a pathogen Thorough excision of infected tissue is a key determinant of outcome Long-term antibiotics may be used for patients who are not suitable for major revision surgery

Management

- Acute osteomyelitis can be treated with antibiotics alone, when the diagnosis is made within 2–3 days of onset of symptoms, . Sta - there is no dead bone on imaging and there is no adjacent - septic arthritis. Culture results help to guide therapy , so blood cultures should be taken, and radiologically guided sampling should be considered. Empirical intravenous therapy against Gram-positive organisms is given (cephalosporins or flucloxa -). cillin), adding gentamicin to cover Gram-negative organisms in children under 1 year. The limb should be splinted and good analgesia given. Intravenous antibiotics should be converted to oral therapy , depending on clinical progress and the results of cultures, and therapy is continued for a total of 2–3 weeks. If the patient does not respond rapidly , if the limb deteriorates or if there is imaging evidence of progression of disease, surgery is indi - cated to prevent bone destruction and the onset of chronic osteomyelitis. With prompt treatment, acute bone infection has a good - prognosis with a 90% cure rate.

> Failure to tr eat adequa tely pro - duces chronicity , with recurrent infection over many years. In children, the adjacent growth plates and joints may be a ff ected with subsequent deformity and joint destruction. Summary box 43.8 Acute osteomyelitis /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF Gavriil Abramovich Ilizarov , 1921–1992, orthopaedic surgeon, Kurgan, Western Siberia, Russia, pioneered this eponymous approach to bone reconstruction in the 1960s for the management of osteomyelitis, fractures and limb deformities.

(c) Figure 43.7 (a) Radiograph of a complex distal tibia fracture that was internally /f_i xed but complicated by deep infection. plate was loose and grossly infected. (c) The plate and all infected tissue was excised. Deep samples were sent for microbiology and histology. The defect at the lower end was /f_i lled with an absorbable antibiotic carrier. and the skin primarily closed. Presents in children with toxaemia, fever and unwillingness to move the limb May affect the vertebral column in adults, where back pain may be the only symptom Radiographs may be normal for up to 1 week so are of limited value in early diagnosis MRI is the investigation of choice WCC and CRP are usually raised Early diagnosis is treated with high dose intravenous antibiotics, started empirically and modi /f_i ed with culture results Late diagnosis and/or failure of medical treatment requires surgical debridement (d) (b) At operation, the (d) The bone was stabilised with an Ilizarov circular external /f_i xator

Management

The BACH classification divides patients into 'uncomplicated', 'complex' and 'limited options available' based on the four important features of the infection (Figure 43.9). These are: the anatomical location in the bone (B), the antimicrobial profile (A), the need for soft-tissue cover (C) and the health of the host (H). Treatment must always address all four parts of the classification to achieve good outcomes. All infected unhealed fractures and infected non-unions are complex. As with PJI, comorbidities should be optimised before sur - gery . The interaction between the patient's health status and the extent of the bone infection greatly a ff ects the outcome after surgery . In chronic infection, it is essential to address med - ical conditions that ma y impair wound healing (e.g. smoking, peripheral vascular disease, diabetes, steroid use) prior to sur - gery . This approach has been shown to improve cure rates. A joint assessment by an orthopaedic sur geon, plastic surgeon and infectious disease physician will allow good preoperative planning.

B one involvement A ntimicrobial options Ax B1 Unknown/culture negative Cavitary ed involvement cat A1 (including medullary, pli <4 resistant tests cortical and om ≥ 80% susceptibility tests non-segmental Unc sensitive corticomedullary) A2 B2

> 4 resistant tests Segmental <80% susceptibility tests involvement lex sensitive Any infection with Comp joint involvement A3 B3 Sensitivity to either 0 or 1 Whole bone susceptibility test involvement Limited options Figure 43.9 The BACH classi /f_i cation of osteomyelitis. (a) Coronal computed tomography scan of the femur (b) A transverse section C overage of soft tissue H ost status H1 C1 Patient /f_i t and well or has Direct closure possible well-controlled disease

> Plastic surgery expertise not required H2 C1 Patient with either poorly Direct closure not possible controlled disease, severe Plastic surgery expertise disease or recurrent required osteomyelitis H3 Un /f_i t for anaesthetic Patient declines surgery Surgery not indicated

In uncomplicated disease, excision of the dead bone, with local and systemic antibiotics and direct wound closure, is highly e ﬀ ective (Figure 43.10). If more than one-third of the cortical circumference is excised, splintage is essential, often with external fixation to prevent fracture. Secondary bone grafting may be needed. When the infection is segmental (BACH complex), or when the soft-tissue envelope cannot be closed directly , major recon struction will be required. Curative resection must be segmen tal and bone stabilisation will always be required. The Ilizarov method, which uses distraction osteogenesis to fill bone defects, is a powerful and successful technique in these cases. It can be combined with free tissue transfer. T his allows reconstruction to proceed in parallel with rehabilitation. After surgery , patients should be given antibiotics. In total segmental excision of infection a short course may be indicated, but in most chronic infections 6–12 weeks is often advised. If there is any doubt about the adequacy of removal of the dead bone , a long antibiotic course will be needed and recurrence will be more likely . In chronic fracture-related infection, anti biotics should continue until fracture union. There is now increasing interest in the use of local antibiotic absorbable carriers. These can deliver high doses of antibiotics into the bone, without systemic e ﬀ ects. Some ceramic ma (with hydroxyapatite) can form new bone in the defect, avoid ing the need for secondary bone grafting. Chronic osteomyelitis /uni25CF /uni25CF /uni25CF

Figure 43.10 (a) This magnetic resonance imaging scan shows a BACH uncomplicated medullary osteomyelitis of the femur. (b) infected bone has been removed by reaming and the central defect /f_i lled with absorbable calcium sulphate pellets with gentamicin. Chronic disease requires specialist surgery with excision, stabilisation and reconstruction Host status should be optimised before surgery Following surgery, antibiotic therapy is typically continued for at least 6 weeks

Management

Successful treatment requires accurate diagnosis and a multi - disciplinary approach to deliver a package of care, summarised as follows: /uni25CF Preoperative: /uni25CF patient assessment and clinical staging of disease; /uni25CF full discussion of all treatment options with potential complications; /uni25CF diagnostic tests for general health; /uni25CF optimisation of patients and treatment of comorbid - ities. /uni25CF Operative: /uni25CF exposure for multiple, deep bone sampling; /uni25CF excision of all a ﬀ ected tissue; /uni25CF intravenous antibiotics after sampling; /uni25CF bone stabilisation, if necessary; /uni25CF dead-space management; /uni25CF soft-tissue cover, which may include plastic surgery . /uni25CF Postoperative: /uni25CF functional rehabilitation; /uni25CF continued antimicrobial therapy guided by culture re - sults, with regular clinical monitoring. - The principles listed above dictate that a range of surgical and medical specialists will be needed to treat patients with bone and joint infections. If the patient is systemically well, ved tions, optimise patient there is often time to complete investiga health and plan interventions. Complex infections should be referred early to centres that specialise in these cases. Atten - tion to diabetes control, peripheral vascular disease, nutrition and smoking cessation is essential. Many patients will benefit from psychological support or at least good counselling around the di ffi culties of eradicating infection and the components of treatment.

Mag

Management

Surgical management Medical treatment alone is rarely indicated in joint sepsis. Prompt surgical drainage is a priority to avoid further damage to the cartilage. Arthroscopic washout is commonly performed but it may be di ffi cult to remove loculated areas of infection. Washout should be with Ringer's solution or of the risk of chondrolysis. There should be a low threshold for open arthrotomy , particularly if a joint is not settling. A synovectomy is recommended if there is major synovial thickening, aggressive synovitis or subchondral erosions seen on radiology (Gächter stages 3 and 4). Inadequate clearance may lead to chronic infection with destruction of the joint (Figure 43.4). Treatment may then require joint excision, joint fusion or staged joint replacement. Medical management Antibiotics are usually given for 3–6 weeks (beginning with intravenous therapy). There are sparse data to guide duration. Longer courses should be considered if the infection is slow to resolve, if more than one washout is required, if the patient is bacteraemic and/or if the infection is caused by S. aureus choice of antibiotics is as given in Summary box 43.4 . Summary box 43.6 Native joint septic arthritis /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF

Most common at extremes of age, in patients with rheumatoid arthritis and in association with immunocompromise Most commonly affects hips in neonates and knees in adults and children The commonest pathogen is S. aureus Joints should be aspirated for microbiology before starting antibiotics, if safe to do so Management is prompt surgical joint washout, followed by 3–6 weeks of antibiotics

Management

A multidisciplinary approach is required, including ortho paedics, plastic surgery , infectious diseases/microbiology , α pharmacy , nursing, occupational therapy and physiotherapy , centred on the patient's understanding and wishes regarding their condition. Many patients have other medical comorbid - ities tha t should also be addressed and optimised. PJI can be - associated with a range of emotional, psychological and mental health issues, ranging from anger about surgical complications to depression arising from chronic symptoms, lack of function and prolonged hospitalisation. T he choice of surgical strategy for prosthetic joints can be categorised as: /uni25CF salvage of an infected implant; /uni25CF removal of the infected implant with or without reimplan - - tation.

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Well- /f_i xed prostheses may be Debrided, treated with Antibiotics and the Implant Retained (‘DAIR’ approach) Loose prostheses must be removed Replacement can be made at the initial surgery (one stage) or after a delay to allow infection to be eradicated with antibiotics (two stage) Multiple surgical samples are crucial for identifying a pathogen Thorough excision of infected tissue is a key determinant of outcome Long-term antibiotics may be used for patients who are not suitable for major revision surgery

Management

- Acute osteomyelitis can be treated with antibiotics alone, when the diagnosis is made within 2–3 days of onset of symptoms, . Sta - there is no dead bone on imaging and there is no adjacent - septic arthritis. Culture results help to guide therapy , so blood cultures should be taken, and radiologically guided sampling should be considered. Empirical intravenous therapy against Gram-positive organisms is given (cephalosporins or flucloxa -). cillin), adding gentamicin to cover Gram-negative organisms in children under 1 year. The limb should be splinted and good analgesia given. Intravenous antibiotics should be converted to oral therapy , depending on clinical progress and the results of cultures, and therapy is continued for a total of 2–3 weeks. If the patient does not respond rapidly , if the limb deteriorates or if there is imaging evidence of progression of disease, surgery is indi - cated to prevent bone destruction and the onset of chronic osteomyelitis. With prompt treatment, acute bone infection has a good - prognosis with a 90% cure rate.

Failure to tr eat adequa tely pro - duces chronicity , with recurrent infection over many years. In children, the adjacent growth plates and joints may be a ff ected with subsequent deformity and joint destruction. Summary box 43.8 Acute osteomyelitis /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF Gavriil Abramovich Ilizarov , 1921–1992, orthopaedic surgeon, Kurgan, Western Siberia, Russia, pioneered this eponymous approach to bone reconstruction in the 1960s for the management of osteomyelitis, fractures and limb deformities.

(c) Figure 43.7 (a) Radiograph of a complex distal tibia fracture that was internally /f_i xed but complicated by deep infection. plate was loose and grossly infected. (c) The plate and all infected tissue was excised. Deep samples were sent for microbiology and histology. The defect at the lower end was /f_i lled with an absorbable antibiotic carrier. and the skin primarily closed. Presents in children with toxaemia, fever and unwillingness to move the limb May affect the vertebral column in adults, where back pain may be the only symptom Radiographs may be normal for up to 1 week so are of limited value in early diagnosis MRI is the investigation of choice WCC and CRP are usually raised Early diagnosis is treated with high dose intravenous antibiotics, started empirically and modi /f_i ed with culture results Late diagnosis and/or failure of medical treatment requires surgical debridement (d) (b) At operation, the (d) The bone was stabilised with an Ilizarov circular external /f_i xator

Management

The BACH classification divides patients into ‘uncomplicated’, ‘complex’ and ‘limited options available’ based on the four important features of the infection (Figure 43.9). These are: the anatomical location in the bone (B), the antimicrobial profile (A), the need for soft-tissue cover (C) and the health of the host (H). Treatment must always address all four parts of the classification to achieve good outcomes. All infected unhealed fractures and infected non-unions are complex. As with PJI, comorbidities should be optimised before sur - gery . The interaction between the patient’s health status and the extent of the bone infection greatly a ff ects the outcome after surgery . In chronic infection, it is essential to address med - ical conditions that ma y impair wound healing (e.g. smoking, peripheral vascular disease, diabetes, steroid use) prior to sur - gery . This approach has been shown to improve cure rates. A joint assessment by an orthopaedic sur geon, plastic surgeon and infectious disease physician will allow good preoperative planning.

B one involvement A ntimicrobial options Ax B1 Unknown/culture negative Cavitary ed involvement cat A1 (including medullary, pli <4 resistant tests cortical and om ≥ 80% susceptibility tests non-segmental Unc sensitive corticomedullary) A2 B2

> 4 resistant tests Segmental <80% susceptibility tests involvement lex sensitive Any infection with Comp joint involvement A3 B3 Sensitivity to either 0 or 1 Whole bone susceptibility test involvement Limited options Figure 43.9 The BACH classi /f_i cation of osteomyelitis. (a) Coronal computed tomography scan of the femur (b) A transverse section C overage of soft tissue H ost status H1 C1 Patient /f_i t and well or has Direct closure possible well-controlled disease

> Plastic surgery expertise not required H2 C1 Patient with either poorly Direct closure not possible controlled disease, severe Plastic surgery expertise disease or recurrent required osteomyelitis H3 Un /f_i t for anaesthetic Patient declines surgery Surgery not indicated

In uncomplicated disease, excision of the dead bone, with local and systemic antibiotics and direct wound closure, is highly e ff ective (Figure 43.10). If more than one-third of the cortical circumference is excised, splintage is essential, often with external fixation to prevent fracture. Secondary bone grafting may be needed. When the infection is segmental (BACH complex), or when the soft-tissue envelope cannot be closed directly , major recon struction will be required. Curative resection must be segmen tal and bone stabilisation will always be required. The Ilizarov method, which uses distraction osteogenesis to fill bone defects, is a powerful and successful technique in these cases. It can be combined with free tissue transfer. T his allows reconstruction to proceed in parallel with rehabilitation. After surgery , patients should be given antibiotics. In total segmental excision of infection a short course may be indicated, but in most chronic infections 6–12 weeks is often advised. If there is any doubt about the adequacy of removal of the dead bone , a long antibiotic course will be needed and recurrence will be more likely . In chronic fracture-related infection, anti biotics should continue until fracture union. There is now increasing interest in the use of local antibiotic absorbable carriers. These can deliver high doses of antibiotics into the bone, without systemic e ff ects. Some ceramic ma (with hydroxyapatite) can form new bone in the defect, avoid ing the need for secondary bone grafting. Chronic osteomyelitis /uni25CF /uni25CF /uni25CF

Figure 43.10 (a) This magnetic resonance imaging scan shows a BACH uncomplicated medullary osteomyelitis of the femur. (b) infected bone has been removed by reaming and the central defect /f_i lled with absorbable calcium sulphate pellets with gentamicin. Chronic disease requires specialist surgery with excision, stabilisation and reconstruction Host status should be optimised before surgery Following surgery, antibiotic therapy is typically continued for at least 6 weeks

Microbiology

Microbiology

Virulent Gram-positive organisms, particularly Staphylococcus - aureus , are the most common cause of bone or joint infection in native tissue. However, once prosthetic material is implanted, a wide range of organisms can be involved. This includes - organisms with low virulence that are usually considered skin commensals, such as coagulase-negative staphylococci, α -haemolytic streptococci and Cutibacterium acnes (Table 43.1). e Microbiology

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NATIVE JOINT SEPTIC ARTHRITIS Epidemiology

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Bacterial infection of native joints occurs with an estimated incidence of 4–10 per 100 /uni00A0 000 population per year in western Europe, with higher rates associated with socioeconomic deprivation and in developing countries. The condition most characteristically a ff ects patients at extremes of age, usually with pre-existing arthropathy or immunocompromise (Table 43.2 Joint infection may arise as a result of haematogenous dis semination of bacteria from another focus (e.g. endocarditis) or may occur as a result of direct inoculation or local exten sion from an infected source (e.g. traumatic wound or adjacent osteomyelitis). NATIVE JOINT SEPTIC ARTHRITIS Epidemiology

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PROSTHETIC JOINT INFECTION Epidemiology

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The incidence of PJI is around 1% per joint per year, with upper limb joints at a higher risk. Infection can be minimised with improved operative practice, prophylactic systemic anti biotics, local antibiotics in cement and the use of surgical ‘care bundles’. Risk factors include obesity , skin disease, diabetes, malignancy , inflammatory arthritis, prolonged or complicated surgery , revision surger y , fracture and postoperative wound infection or haematoma. PROSTHETIC JOINT INFECTION Epidemiology

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