

Bone and Joint Infections in the Elderly

Practical Treatment Guidelines

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Abstract

Two types of haematogenous osteomyelitis that are seen in the elderly are vertebral and long bone osteomyelitis. Osteomyelitis secondary to contiguous foci of infection can occur in older adults without vascular insufficiency (secondary to pressure ulcers) or with vascular insufficiency due to diabetes mellitus or peripheral vascular disease from atherosclerosis. Most cases of osteomyelitis can be reasonably treated with adequate drainage, thorough debridement, obliteration of dead space, wound protection, and antimicrobial therapy. Patients are initially given a broad spectrum antimicrobial that is changed to specific antimicrobial

therapy based on meticulous bone cultures taken at debridement surgery or from deep bone biopsies. Surgical management is often required in the treatment of osteomyelitis and includes adequate drainage, extensive debridement of all necrotic tissue, obliteration of dead spaces, stabilisation, adequate soft tissue coverage, and restoration of an effective blood supply.

Bone repair and bone mineral density may be significantly retarded and may be corrected by eliminating risk factors, supplementing the diet with calcium, bisphosphonates, and/or vitamin D, and treating with testosterone and/or estrogen when deficient. Sodium fluoride treatment and anabolic steroids may be used as alternatives.

Septic arthritis is a medical emergency, and prompt recognition and rapid and aggressive treatment are critical to ensuring a good prognosis. The treatment of septic arthritis includes appropriate antimicrobial therapy and joint drainage.

Adverse effects of prescribed antibacterials occur more often in the elderly patient than in young adults. The physician can help to minimise the incidence of adverse effects and improve outcomes by being aware of the principles of clinical pharmacology, the characteristics of specific drugs, and the special physical, psychological and social needs of older patients.

The elderly are more susceptible than younger adults to a number of infections, and therefore they may be considered immunocompromised. Although normal bone and joints in the elderly are resistant to infection, osteomyelitis and infectious arthritis can occur from a large inoculation of organisms, trauma leading to bone damage, or the presence of foreign bodies. However, the risk of infection increases with the presence of pre-existing medical conditions which locally and/or systemically compromise the patient (table I).^[1]

Infection of the bone may occur either secondary to haematogenous spread of infection or a contiguous focus of infection. Contiguous focus osteomyelitis can be subdivided into those occurring in the presence or absence of generalised vascular insufficiency. Osteomyelitis in the elderly is often subtle or atypical in presentation compared with that in infants, children and young adults. Aggressive diagnosis, and antimicrobial and surgical therapy can result in successful management of this infection.

1. Haematogenous Osteomyelitis

Haematogenous osteomyelitis accounts for 20% of the total cases of osteomyelitis and is more common in males of any age. Two types of haematog-

enous osteomyelitis seen in the elderly are vertebral and long bone osteomyelitis.

1.1 Vertebral Osteomyelitis

1.1.1 Epidemiology

Vertebral osteomyelitis in the elderly population is usually haematogenous in origin but may be secondary to trauma. The lumbar vertebral bodies are most often involved, followed in frequency by the thoracic and cervical vertebrae. The infection is usually monomicrobial when haematogenous in origin. Whereas *Staphylococcus aureus* remains the most commonly isolated organism, aerobic Gram-negative rods are isolated in 30% of cases. Common primary

Table I. Systemic and local factors that affect immune surveillance, metabolism and local vascularity

Local	Systemic
Major vessel compromise	Diabetes mellitus
Small and medium vessel disease	Renal or hepatic failure
Extensive scarring	Malnutrition
Arteritis	Chronic hypoxia
Radiation fibrosis	Immunosuppression or immune deficiency
Chronic lymphoedema	Malignancy
Tobacco abuse (≥ 2 packs per day)	Immune disease
Neuropathy	Extremes of age
Venous stasis	Detrimental drug interactions

sources of infection in the elderly include the genitourinary tract, skin and soft tissue, respiratory tract, infected intravenous catheter sites, postoperative wound infections, endocarditis or dental infection. However, the primary infection focus frequently remains unknown in an elderly patient with vertebral osteomyelitis. While uncommon in the elderly, intravenous drug abuse is associated with a high incidence of infection by *Pseudomonas aeruginosa* and *Serratia marcescens*.^[2] Unusual pathogens such as fungi may also cause haematogenous osteomyelitis in the elderly patient.

1.1.2 Treatment

Elderly patients with vertebral osteomyelitis may be treated with antimicrobial therapy (table II) and bed rest alone if the infection has not progressed to the point of causing extensive bone destruction. We suggest an antimicrobial regimen of 4 weeks' intravenous antibacterials. As with all forms of osteomyelitis, the choice of antimicrobial therapy should be based on meticulous bone or blood cultures and sensitivity results. Erythrocyte sedimentation rates should be monitored to gauge the success of treatment. Using scanning techniques may also provide an indication of patient response to therapy. While radiographic tests can be useful, favourable response to therapy may often progress for several weeks before being detected on plain films. Magnetic resonance imaging (MRI) is clearly superior to radiography in the early detection and evaluation of vertebral osteomyelitis.^[4] Computed tomography (CT) is very useful in detecting sequestra, and guiding bone biopsy for cultures and histology. Radionuclide scans demonstrate excellent sensitivity, usually detecting the infectious process within a few days of infection. However, these scans are not specific and often give false positives for noninfectious reactive bone formation such as that which occurs following trauma or surgery.^[4] For patients with vertebral osteomyelitis, the most beneficial scan is MRI, followed by CT and gallium⁶⁷ citrate scans.

Surgical debridement is usually not necessary when the infection is diagnosed early. However, when epidural and paravertebral abscesses develop,

surgical drainage (sometimes emergently) is necessary. Surgical stabilisation in the form of fusion of vertebrae is not recommended in routine cases, since spontaneous bony fusion often occurs after months or years with appropriate therapy. Other forms of stabilisation, such as plaster body casting, are also not usually necessary, since neck or body braces or a moulded plastic jacket can usually provide adequate stabilisation. In patients where the infection progresses to the point of neurological defects, emergent surgical intervention and decompression should be performed. Also, the development or progression of bone destruction or failure of patient improvement with antibacterial treatment often warrants the use of surgical debridement and stabilisation. The regimen of 4 weeks of intravenous antibacterial followed by 2 to 4 weeks of oral therapy should also be used after the last major debridement. Although there is a need for a prospective study analysing the efficacy of oral antibacterials following an intravenous regimen, we have had good success with this regimen in the treatment for long bone and vertebral osteomyelitis (data not discussed here).

1.1.3 Outcome

Treatment results vary and recurrence of osteomyelitis has been reported to occur in 3 to 40% of patients.^[5] However, the rate of chronic cases of vertebral osteomyelitis (patients demonstrating symptoms after 2 years) has been reduced and has ranged between 0 and 10% in recent studies.^[6] The mortality from this disease in the antibacterial era has been less than 5%.^[5] Residual neurological deficits may be expected to occur in less than 7% of survivors but rates of up to 20% have been reported.^[5,7] Generally, the best way to reduce the morbidity and mortality associated with vertebral osteomyelitis is to limit the time between onset of symptoms and initiation of appropriate therapy.

1.2 Haematogenous Long Bone Osteomyelitis

1.2.1 Epidemiology

Instances of long bone haematogenous osteomyelitis in elderly patients without implants are

Table II. Choice of antibacterial and regimen for treatment of osteomyelitis in elderly patients

Organism	Antibacterials of first choice ^a	Alternative antibacterials
Methicillin-sensitive <i>Staphylococcus aureus</i>	Nafcillin 2g q6h or clindamycin 900mg q8h ^b	Cefazolin
Methicillin-resistant <i>S. aureus</i>	Vancomycin 1g q12h ^b	Cotrimoxazole (trimethoprim-sulfamethoxazole) or minocycline + rifampicin (rifampin)
<i>S. epidermidis</i>	Vancomycin 1g q12h ^b or nafcillin 2g q6h	Cefazolin, clindamycin
Group A streptococcus	Clindamycin 900mg q8h	Benzylpenicillin (penicillin G), cefazolin
Group B streptococcus	Clindamycin 900mg q8h	Benzylpenicillin, cefazolin
<i>Enterococcus</i> spp.	Ampicillin 2g q6h ± gentamicin 5 mg/kg/day q8h ^b	Vancomycin
<i>Escherichia coli</i>	Ampicillin 2g q6h	Cefazolin, gentamicin, ^b levofloxacin
<i>Proteus mirabilis</i>	Ampicillin 2g q6h	Cefazolin, gentamicin, ^b levofloxacin
<i>P. vulgaris</i> , <i>P. rettgeri</i> , <i>Morganella morganii</i>	Cefotaxime 2g q6h ± gentamicin 5 mg/kg/day q8h ^b	Ticarcillin-clavulanic acid, levofloxacin
<i>Serratia marcescens</i>	Cefotaxime 2g q6h ± gentamicin 5 mg/kg/day q8h ^b	Ticarcillin-clavulanic acid, levofloxacin
<i>Pseudomonas aeruginosa</i>	Ceftazidime 2g q8h ± tobramycin 5 mg/kg/day q8h ^b	Ciprofloxacin, amikacin, ticarcillin-clavulanic acid
<i>Bacteroides fragilis</i> group	Clindamycin 900mg q8h	Metronidazole, ampicillin-sulbactam
<i>Peptostreptococcus</i> spp.	Clindamycin 900mg q8h	Metronidazole, ampicillin-sulbactam
<i>Candida</i> /coccioidial spp.	Amphotericin B 2g followed by fluconazole for indefinite course	
<i>Blastomyces</i> spp.	Fluconazole 400 mg/day	
Tuberculous species	Same 12-month antibacterial course as used for pulmonary tuberculosis	
<i>Actinomyces</i> spp.	Up to 6 months of therapy	
<i>Brucella</i> spp.	Cotrimoxazole + rifampicin 3 months	

a Because of age-related decline in renal function, estimation of creatinine clearance should be performed and ideal bodyweight should be used to calculate appropriate dosage for the elderly (i.e. via the standard Cockcroft/Gault equation).^[3]

b Dose should be individualised with serum concentration monitoring.

qxh = every x hours.

rare. In the elderly the most common scenario is reactivation of a site of quiescent haematogenous osteomyelitis acquired during childhood. Reactivation of osteomyelitis may occur secondary to local bone or adjacent soft tissue trauma. However, any reduction in host defences may allow quiescent walled-off organisms to be released, leading to the reactivation of the site of haematogenous osteomyelitis. When such reactivation occurs, a single pathogenic organism is almost always recovered from the bone.^[8,9] The most common bone isolates are coagulase-negative *Staphylococcus*, methicillin-sensitive *S. aureus* and methicillin-resistant *S. epidermidis*; the most common Gram-negative organism is *P. aeruginosa* and the most common anaerobe is *Peptostreptococcus*. However, in the immunocompromised patient, other organisms must also be considered, including fungi and mycobacteria.

1.2.2 Diagnosis

Both the diagnosis and antimicrobial therapy of long bone osteomyelitis are based on the isolation of the pathogen(s) from the bone lesion, blood or joint cultures.^[10] In haematogenous osteomyelitis, positive blood or joint cultures can often obviate the need for a bone biopsy when there is radiographic or radionuclide scan evidence of osteomyelitis. If possible, cultures should be obtained either before antibacterials are initiated or after the patient has been off antibacterial therapy for at least 24 to 48 hours. Sinus tract cultures are not reliable for isolating causative organisms other than *S. aureus*.^[11] Cultures should always be taken to appropriately select the correct antibacterial management. Aerobic, anaerobic and fungal cultures should be obtained at the time of debridement surgery. Bone biopsies are not suggested, since there are 'skip areas' in the involved bone where no organisms are present.

Scanning techniques are often useful during treatment of haematogenous osteomyelitis. However, radiographic improvement may lag behind clinical recovery when the patient is undergoing appropriate antimicrobial therapy.^[12] Additional changes may be seen with more severe infections. Radionuclide scans,^[13,14] CT^[15,16] or MRI^[17,18] scans may be obtained to help gauge the extent of bone and soft tissue involvement. However, it is not usually necessary to obtain these scans for long bone osteomyelitis. In patients with suspected osteomyelitis, the order in which the scans should be performed after the radiograph are the CT, MRI, technetium (3-phase) followed by indium-labelled white blood cell (WBC) scan, and finally a gallium⁶⁷ citrate scan.

1.2.3 Therapy

Appropriate therapy of osteomyelitis includes adequate drainage, thorough debridement, obliteration of dead space, wound protection and antimicrobial therapy.^[10,19] Surgical management of osteomyelitis can be very challenging. The principles of treating any infection are equally applicable to the treatment of infection in bone.^[10] These include adequate drainage, extensive debridement of all necrotic tissue, obliteration of dead spaces, stabilisation, adequate soft tissue coverage and restoration of an effective blood supply.^[10] The number of surgical procedures performed to achieve these goals increases with the severity of the infection, and procedures can be divided into 4 categories.

Category 1: Removal of Necrotic Tissue

Removal of necrotic tissue by extensive debridement surgery is the foundation of osteomyelitis treatment. It is the most commonly performed procedure and patients may require multiple debridements. The goal of debridement is to leave healthy, viable tissue. However, even when all necrotic tissue has been adequately debrided, the remaining bed of tissue must be considered contaminated with the responsible organism. Debridement should be direct, atraumatic and executed with reconstruction in mind. All dead or ischaemic hard and soft tissue is excised unless a noncurative procedure has been chosen. Surgical excision of bone is carried down to

uniform Haversian or cancellous bleeding, termed the paprika sign.^[11]

Category 2: Dead Space Obliteration

Adequate debridement may leave a large bony defect termed dead space, and appropriate management of dead space is mandatory to arrest the disease and to maintain the integrity of the skeletal part. The goal of dead space management is to replace dead bone and scar tissue with durable vascularised tissue. Local tissue flaps or free flaps may be used to fill dead space.^[20-22] An alternative technique is to place cancellous bone grafts beneath local or transferred tissues where structural augmentation is necessary. Careful preoperative planning is critical to conservation of the patient's limited cancellous bone reserves. Open cancellous grafts without soft tissue coverage are useful when a free tissue transfer is not a treatment option and local tissue flaps are inadequate.^[23] Complete wound closure should be attained whenever possible. Suction irrigation systems are not recommended because of the high incidence of associated nosocomial infections and the unreliability of these setups.^[24,25] Secondary intention healing is also discouraged, since the scar tissue that fills the defect may later become avascular.

Antibacterial-impregnated acrylic beads can be used to sterilise and temporarily maintain dead space.^[26-29] The beads are usually removed within 2 to 4 weeks and replaced with a cancellous bone graft. The most commonly used antibacterials in beads are vancomycin, tobramycin and gentamicin. Local delivery of antibacterials, such as amikacin or clindamycin, into dead space can also be achieved with an implantable pump.^[30] Adequate soft tissue coverage of the bone is necessary to arrest osteomyelitis. Most soft tissue defects are closed by primary closure. Small soft tissue defects may be covered with a split thickness skin graft. In the presence of a large soft tissue defect or an inadequate soft tissue envelope, local muscle flaps and free vascularised muscle flaps may be placed in a 1- or 2-stage procedure.^[31]

Category 3: Soft Tissue Coverage

Soft tissue coverage may be achieved by split thickness skin grafts or local or vascularised muscle flaps. Local muscle flaps and free vascularised muscle transfers improve the local biological environment by bringing in a blood supply important in host defence mechanisms, antibacterial delivery and osseous and soft tissue healing. In combination with antibacterials and surgical debridement of all nonviable osseous and soft tissue for chronic osteomyelitis, local and free muscle flaps have a success rate ranging from 66 to 100%.^[32]

Category 4: Stabilisation

If movement is present at the site of infection, measures must be taken to achieve permanent stability of the skeletal unit. Stabilisation may be achieved by external/open reduction or by internal fixation, using an external fixator and/or plates, screws and rods. One type of external fixation allows reconstruction of segmental bone defects and difficult infected nonunions.^[33] The Ilizarov external fixation method uses the theory of distraction histogenesis, whereby bone is fractured in the metaphyseal region. Growth of new bone in the metaphyseal region pushes a segment of healthy bone into the defect left by surgery. The Ilizarov technique is used for difficult cases of osteomyelitis when stabilisation and bone lengthening are necessary.^[34] It can also be used to compress nonunions and correct malunions, and in a small group of patients for reconstruction of difficult deformities that result from osteomyelitis. However, this technique is labour intensive and requires an extended period of treatment averaging 9 months in the device. Furthermore, the Ilizarov pins commonly become infected and the device is painful.

Infected pseudoarthrosis with segmental osseous defects can be treated by debridement and microvascular bone transfers.^[35] Vascularised bone transfer is also useful for the treatment of infected segmental osseous defects of long bones that are >3cm in length. Vascularised bone transfers can be placed after 1 month of inactive sepsis.

Surgical procedures for long bone osteomyelitis can be tailored to the specific anatomy of the bone

infection. When the nidus of infection is entirely within the medullary canal of the bone, surgical treatment is usually more straightforward than in other types of bone involvement. Patients are surgically treated with a thorough intramedullary reaming, and unroofing is usually performed with or without bone grafting. Soft tissues are reapproximated and the limb is protected by external means (brace or cast) until the structural integrity of the bone is re-established by normal remodelling. When osteomyelitis is characterised by a full thickness, cortical sequestration, patients can usually be treated with removal of the dead infected bone (bone saucerisation). Bone grafting may be necessary to augment structural support. These patients may require external fixation for structural support while the bone graft incorporates. Complex reconstruction of both bone and soft tissue is frequently necessary.

In some cases, osteomyelitis progresses to an infection involving a segmental section of the bone. These patients often require an intercalary resection of the bone to arrest the disease process. Since this advanced stage of osteomyelitis involves an entire through-and-through section of bone, there is a loss of bone stability either before or after debridement surgery. As a result, treatment often must be directed toward establishing structural stability and obliterating debridement gaps by means of cancellous bone grafts or the Ilizarov technique (see above in this section). Free flaps and vascularised bone grafts are other possible treatment modalities. All of the modalities previously discussed may have a place in the treatment of this type of osteomyelitis.

After surgery, patients are initially given a broad spectrum antibacterial that is changed to specific antimicrobial therapy based on meticulous bone cultures taken at debridement surgery or from deep bone biopsies.^[10,19,36] Antimicrobial regimens for specific pathogens usually associated with osteomyelitis are listed in table II. We recommend 2 weeks of intravenous antibacterial therapy followed by 4 weeks of oral therapy except in cases of candidiasis, blastomycosis, tuberculosis, actinomycosis and brucellosis of the bone.

If the patient is a compromised host, an effort is also made to correct or improve the host defect(s). These include improving the nutritional, medical and vascular status of the patient and treating any underlying diseases. Host factors are primarily involved with containment of the infection once it is introduced adjacent to or into bone.^[1] A systemically and/or locally compromised host does not contain the infection as well as a normal host, and the infection may permeate the bone. Host deficiencies that lead to bacteraemia favour the development of haematogenous osteomyelitis. While surgical management is usually initiated prior to antimicrobial therapy, there are instances when antibacterials are given first. Examples of these situations include delaying surgical treatment when the treatment is worse than the disease or when the patient's condition is serious. Under these conditions, patients are treated with antimicrobial therapy until they have stabilised. Antibacterials are then halted for 2 to 3 days and surgical management is performed.

2. Contiguous Focus Osteomyelitis Without Generalised Vascular Insufficiency

Osteomyelitis secondary to contiguous foci of infection accounts for at least half of all cases. Two recent studies have documented a decline in haematogenous osteomyelitis accompanied by a rise in contiguous disease.^[37] The infection occurs in younger individuals secondary to trauma and related surgery, and in older adults secondary to pressure ulcers (e.g. decubitus ulcers).

In contrast to haematogenous osteomyelitis, multiple organisms are usually isolated from the bone in contiguous focus osteomyelitis. *S. aureus* and coagulase-negative staphylococci account for 75% of bacterial isolates.^[8] However, Gram-negative bacilli and anaerobic organisms are frequently isolated. While blood cultures are only occasionally positive, if positive they are invaluable for selecting culture-directed antibacterials. In the elderly patient, it may be useful to analyse serum albumin levels and determine ideal bodyweight versus actual bodyweight to determine the state of nutrition.

An important factor in restoring immune function and promoting healing is the correction of nutritional deficiencies.

Loss of bone stability, bone necrosis and soft tissue damage occur frequently, making this form of osteomyelitis difficult to treat. Surgical debridement of infected bone and soft tissue provide specimens for culture and hasten eradication of the infection. Other steps in the surgical management of contiguous focus osteomyelitis should be tailored to the specific anatomy of the bone infection as is done in cases of haematogenous long bone osteomyelitis (section 1.1.2). Antimicrobial therapy should begin with a broad spectrum antibacterial that is changed to specific antimicrobial therapy based on meticulous bone cultures taken at debridement surgery or from deep bone biopsies (see table II).^[10,19,36] If the patient is a compromised host (table I), an effort is made with adjunctive therapy to correct or improve the host deficit(s) [table III]. This includes improving the nutritional, medical and vascular status of the patient and treating any underlying diseases.

3. Contiguous Focus Osteomyelitis With Generalised Vascular Insufficiency

The majority of patients with osteomyelitis in this category have diabetes mellitus or peripheral vascular disease from atherosclerosis. In these patients, two main types of contiguous focus osteomyelitis infections occur: osteomyelitis involving the small bones of the feet and malignant external otitis.

3.1 Diabetic Foot Infections

The small bones of the feet, and the talus, calcaneus, distal fibula and tibia are commonly involved in this category of infection. The infection is usually initiated in soft tissue by minor trauma of the feet, such as infected nail beds, cellulitis or a trophic skin ulceration. The diminished arterial blood supply has traditionally been considered to be the major predisposing factor. Recent observation suggests that neuropathy is an equally important factor in patients with diabetes mellitus. Identifiable neu-

Table III. Adjunctive therapy in patients with bone or joint infections

Therapy	Patient subgroups likely to benefit
Nutritional supplementation	Malnourished Alcohol abuse Diabetes mellitus Immunocompromised Renal/hepatic failure
Hyperbaric oxygen	Ciorny-Mader stages 3-4 BI ^a Poor granulation bed Refractory osteomyelitis
Advice on smoking cessation	Smokers
Pressure garments, local or microvascular tissue transfers	Local compromise
Tight blood glucose control	Diabetes mellitus
Arterial bypass surgery	Major vessel disease
Discontinue or alter medications	Chemical immunosuppression
Emergency decompression or drainage	Sepsis-toxicity

a Patients demonstrating localised or diffuse osteomyelitis and are locally compromised with respect to immune surveillance, metabolism and/or local vascularity.

BI = locally compromised B host (according the Ciorny Mader Staging System).

ropathy as a complication of diabetes mellitus is present in approximately 80% of patients with foot disease.^[38] Multiple organisms are found in patients with osteomyelitis involving the small bones of the feet including *S. aureus*, coagulase-negative staphylococci, *Streptococcus* spp., *Enterococcus* spp., Gram-negative bacilli and anaerobes. Aerobic Gram-negative bacilli are usually a part of mixed infection.^[39] Cultures obtained by deep bone biopsy or during debridement procedures are indispensable in the diagnosis and selection of appropriate antimicrobial therapy. Culture results not only accurately identify responsible pathogens but also identify patients with bone lesions that resemble, but are not, osteomyelitis.

Treatment of this type of osteomyelitis is like that of contiguous focus osteomyelitis without vascular insufficiency. Resection of the infected bone is almost always necessary. However, in patients with compromised vascularity it is extremely important to provide soft tissue coverage after an adequate debridement to bleeding cortex. A split thick-

ness skin graft or local or free tissue transfer may provide tissue coverage. Some investigators recommend the use of hyperbaric oxygen therapy to augment wound healing and promote angiogenesis. Also, amputation may be a viable treatment alternative when there is no acceptable antimicrobial agent (i.e. one to which the organism is susceptible and the patient is not allergic), no response to medical therapy, or no chance at restoring the normal architecture of the foot. The level of amputation depends on the location of the infection and the vascular status of the patient at the involved site. Although arrest of the infection is desirable, a more attainable treatment goal is to suppress the infection and maintain the functional integrity of the involved limb. Recurrent or new bone infections occur in the majority of patients even after appropriate treatment.

3.2 Extension of External Otitis Media

Malignant external otitis, also known as necrotising external otitis, is an unusual but potentially fatal infection that may occur in elderly patients with diabetes mellitus. The treatment consists of local debridement of the external auditory canal granulation tissue and an aggressive course of intravenous antibacterials, administered for at least 4 to 6 weeks. Since most of these infections are mediated through *Pseudomonas* spp., the initial broad spectrum antibacterial regimen should cover this genus.^[40] If necessary, the antibacterial regimen can be adjusted following culture results from samples obtained during debridement of the external auditory canal granulation tissue and subsequent antibacterial sensitivity results. With aggressive therapy, the cure rate has been found to be between 74 and 91%.^[41] Oral antibacterial therapy with the quinolone class of antibacterials has been associated with an improved cure rate. Surgical intervention is currently used only as a last resort. Monitoring the response to therapy is best done with serial CT or gallium/indium scans.

4. Osteoporosis and Osteomyelitis

The surviving bone in the osteomyelitis field usually becomes osteoporotic during the active pe-

riod of infection. Osteoporosis associated with osteomyelitis is the result of the inflammatory reaction and disuse atrophy. This lack of bone mineral density may be exacerbated by age-associated osteoporosis seen in elderly patients. After the infection subsides and function of the part is increased, bone density returns and it may undergo extensive transformation to meet the lines of stress and strain. In time, it may be difficult to distinguish between the old living bone and the newly formed bone. However, bone repair and bone mineral density may be significantly retarded in elderly men and women because of a number of factors (table IV). The reduction in bone mineral density may be corrected by correcting risk factors, supplementing the diet with calcium, bisphosphonates and/or vitamin D, and treating with testosterone and/or estrogen when deficient.^[49-55] Sodium fluoride treatment and anabolic steroids may be used as alternatives.^[56]

5. Joint Infections

Non-gonococcal bacterial arthritis is an infectious process with serious sequelae. Mortality rates as high as 12% have been reported, and up to 75% of survivors develop a significant functional disability of the involved joint.^[57] The classical presentation includes fever, pain, warmth, swelling and decreased range of motion in the involved joint.^[58,59] Aspiration and culture of the joint effusion is critical in determining the causative agent. Whereas *Neisseria gonorrhoeae* is the most common cause of septic arthritis in young healthy North American adults,^[58,60,61] it is very rarely encountered in the

elderly population. Therefore, we will limit our discussion to non-gonococcal arthritis.

5.1 Treatment

Septic arthritis is a medical emergency that can lead to significant morbidity and mortality. Therefore, prompt recognition and rapid and aggressive treatment are critical to ensuring a good prognosis. The treatment of septic arthritis includes both appropriate antimicrobial therapy and joint drainage. Initial antimicrobial therapy is based on the clinical presentation, initial Gram stain and joint fluid analysis. An effective broad spectrum antibacterial should be initiated as soon as possible.

There is a variety of methods to drain the purulent fluid from the infected joint. Presented in ascending order of invasiveness, cost and effectiveness in the thoroughness of drainage, they include needle aspiration, tidal irrigation, arthroscopy and arthrotomy. There are no universally accepted criteria for choosing the drainage method. The specific method of drainage used should be tailored according to the clinical situation of the patient. However, some general guidelines can be made.

Patients should initially be treated with needle aspiration if a joint infection is easily accessible, if almost all the purulent fluid can be removed, and if the patient does not have negative prognostic indicators (see next paragraph). Tidal irrigation is reportedly as effective as arthroscopy and can be performed at the bedside. This closed system irrigation method may be useful when needle aspiration results in incomplete evacuation or when multiple synovial fluid samples demonstrate different characteristics indicating the presence of loculating pockets of infection. Arthroscopic lavage has been increasingly used in the treatment of septic arthritis of the knee. A recent study demonstrated that this method may also be effective for deep joints, such as the hip. Arthroscopy is advantageous in that extensive debridement can be performed with a small incision, thereby allowing for a more rapid and effective rehabilitation period. The comparative efficacy of tidal irrigation versus that of arthroscopy requires further evaluation.

Table IV. Causes of and risk factors associated with decreased bone mineral density in elderly men and women

Vitamin D deficiency and the related hyperparathyroidism ^[42,43]
Reduced bioavailable testosterone (usually due to hypogonadism) ^[44]
Dietary calcium deficiency ^[43]
Reduced bioavailable estrogen and adrenal androgens ^[44,45]
Glucocorticoids ^[46]
Growth hormone and insulin-like growth factor I deficiency ^[47]
Ethanol and tobacco use ^[48]
Inactive lifestyle ^[48]

Arthrotomy should be used when an infected joint must be decompressed urgently because of neuropathy or compromised blood supply, when the infected joint is inaccessible by less invasive methods (such as the hip and sometimes shoulder), when the joint has been damaged by pre-existing disease, when bacterial arthritis is complicated by osteomyelitis, and when the less invasive methods of treatment fail. Also, when the isolated pathogen (e.g. *P. aeruginosa*) can only be treated with aminoglycosides, arthrotomy is often required to overcome the low oxygen tensions and pH of the infected joint. There are also a number of patient factors in septic arthritis that may increase the need for invasive surgical intervention. These negative prognostic indicators include a long period between symptom onset and treatment, complicated joint site, extremes of age, underlying illness, immunosuppressive drugs, underlying joint diseases, presence of juxta-articular osteomyelitis, and repeated failure of less invasive methods to clear the infection as demonstrated by positive blood or synovial fluid cultures, continued back pain and restriction of motion.

Once the pathogenic organism is obtained from joint or blood cultures, optimal antibacterial(s) can be continued. In most patients, septic arthritis is treated with 3 weeks of parenteral antibacterial therapy directed against the isolated micro-organism. The micro-organisms responsible for bacterial arthritis are largely dependent on host factors, including age and risk factors such as intravenous drug abuse, asplenia or joint infection following a domestic dog or cat bite. Whereas *S. aureus* is the most common causative agent of non-gonococcal bacterial arthritis in adults, Gram-negative bacilli account for approximately 20% of cases^[61-65] and *Streptococcus* spp. are responsible for 10 to 15% of cases.^[65,66] Approximately 10% of patients with non-gonococcal septic arthritis have polymicrobial infections. Although not common in elderly patients, intravenous drug abuse often produces significant rates of infection with Gram-negative organisms. The most common Gram-negative organisms causing septic arthritis are *P. aeruginosa* and *Escherichia coli*. Microbiological associations exist with concomitant

disease states. Septic arthritis following cases of infectious diarrhoea may be caused by *Shigella* spp., *Salmonella* spp., *Campylobacter* spp. or *Yersinia* spp.^[42,44] A rare form of migrating polyarthritis may be caused by *Streptobacillus moniliformis*. The initial antibacterial therapy is adjusted, if necessary, on the basis of appropriate culture and sensitivity results.

During the acute phase of bacterial arthritis, bed rest and optimal joint position are absolutely required to prevent the occurrence of joint deformation and deleterious contractures. Splints may be used to maintain proper joint position (hip in neutral rotation in some abduction, knee in full extension, elbow in flexion at 90° and forearm in neutral rotation). Isotonic exercise is often helpful in preventing muscular atrophy. After the acute phase, early physical therapy and aggressive mobilisation are vital for optimal recovery.^[45,61]

5.2 Prognosis

The results of treatment vary greatly with the virulence of the invading organism, adequacy of host defences, integrity of the joint and duration of symptoms prior to treatment. Patients who start treatment after 7 days of onset of symptoms have a very poor outcome. The outcome in patients with septic arthritis due to some of the more virulent organisms such as superantigen-producing *S. aureus* and certain Gram-negative bacilli is poor in spite of optimal therapy.^[58,66] Even with rapid and correct antibacterial treatment, the prognosis for good or excellent function of the joint ranges from 27 to 90%, while the mortality rate is reported to be between 7 and 32%.^[43]

6. Antibacterial Adverse Effects in The Elderly

Individuals older than 65 years constitute 12% of the population of the US, but this segment of the population accounts for about 25 to 30% of the total drug expenditure in developed countries.^[46-48,67] The elderly population is predicted to reach 23% in the US by the year 2030.^[68] The incidence of adverse drug effects is much higher in older patients and

leads to repeated hospitalisations.^[48] This high rate of adverse effects is caused by the complicating factors associated with drug therapy in the elderly including decreased organ reserve capacity, altered pharmacokinetics and pharmacodynamics of drugs, and polypharmacy with associated drug-drug and drug-disease interactions. Also, compliance factors associated with prolonged oral regimens may result in poor treatment outcomes. The patient is often more likely to complete the drug regimen when treatment is accomplished with a simple, once or twice daily oral regimen. The physician can help to minimise the incidence of adverse effects and improve outcomes by being aware of the principles of clinical pharmacology, the characteristics of specific drugs and the special physical, psychological and social needs of older patients.

The most important and best-studied pharmacokinetic alteration that occurs in the elderly is the age-associated decline in renal function. Creatinine clearance is a very useful measure of renal function in elderly patients and can be estimated by the Cockcroft/Gault equation,^[3] in which the creatinine clearance (in ml/min) is assumed to equal the percentage of normal renal function.

Creatinine clearance (ml/min) =

$$\frac{(140 - \text{age}) \times \text{bodyweight (kg)}}{72 \times \text{serum creatinine (mg/dL)}} \times 0.85 \text{ (for females)}$$

Antibacterial loading and maintenance doses should be estimated and confirmed by measuring peak and trough serum concentrations after the fourth dose. Loading dose may be calculated by using the ideal bodyweight to estimate lean mass.^[46]

Ideal bodyweight = [(height in inches - 60) × 2.3] +

50kg (males) or 40kg (for females)

The dose may be adjusted upward or downward to compensate for increased or decreased extracellular fluid volume. Maintenance dose should be estimated using ideal bodyweight and percentage of normal renal function.

Prolonged use of aminoglycosides should be avoided if possible because of increased risk for

ototoxicity and nephrotoxicity in the elderly patient. Monitoring of plasma drug concentrations is important for drugs that have appreciable renal clearance such as vancomycin and aminoglycosides.^[46] In Australia, cases of cholestatic hepatitis were reported in elderly patients (predominantly women) after 3 weeks of flucloxacillin treatment.^[69] The use of amoxicillin-clavulanic acid has also been associated with cholestatic hepatitis. However, this adverse effect was noted primarily in elderly men who had received treatment for >2 weeks.^[70] Because of reports of seizures, the intravenous dose of imipenem 0.5g every 6 hours should be reduced in elderly patients with decreased renal function, cerebrovascular disease or seizure disorders.^[71] Cefamandole may increase creatinine levels in the elderly. Seizures due to hypo- or hyperglycaemia were noted in 4 elderly patients being treated with ofloxacin.^[72] Fluoroquinolones and tetracycline may have decreased oral absorption when coadministered with aluminium- or magnesium-containing antacids or sucralfate. Quinapril, an ACE inhibitor, contains a high concentration of magnesium which may also decrease oral absorption of fluoroquinolones and tetracycline. Rifampicin (rifampin) interaction with a large number of therapeutic agents requires close patient monitoring and follow-up.^[73] It is important to note that potent loop diuretics decrease extracellular fluid volume, thereby elevating serum concentrations of antibacterials and necessitating further reductions in dose levels.

7. Summary and Future Research

Normal bone is highly resistant to infection. Pathogenic organisms reach the bones by direct extension from neighbouring infected soft tissues, through penetrating wounds and open fractures, or by the blood stream. While osteomyelitis in the elderly is often subtle or atypical in presentation when compared with infants, children and young adults, successful management of this infection can result when diagnosis, and antimicrobial and surgical therapy are aggressive. Joint infections should be treated as medical emergencies; prompt recognition, and rapid and aggressive treatment are crit-

ical to ensuring a good prognosis. The treatment of septic arthritis includes appropriate antimicrobial therapy and joint drainage.

The treatment of bone and joint infections in the elderly patient represents a special set of circumstances for surgical and infectious disease specialists. In reference to osteomyelitis, the speed of bone repair following treatment may be significantly retarded in the elderly population. Therefore, eliminating the risk factors associated with deficiencies in bone mineral density may be considered. Whether the infection is associated with the bone or joint, the immunocompromised nature of the elderly patient must be taken into consideration. The general compromised nature of the immune system that occurs in this patient subset, possibly due to age-dependent declines in interleukin-2 and its associated receptor, can make treatment problematic. Also, the elderly have a higher risk of other diseases that often interfere with pathogen clearance and the natural healing process. Therefore, we feel that diagnostic procedures and therapeutic regimens should be appropriate, rapid and aggressive. However, before prescribing any medication or surgical procedure, it must be understood that there is a very real risk of adverse effects and drug toxicity/cross reactivity in the elderly patient. The physician can minimise adverse drug reactions and improve outcomes by being aware of the principles of clinical pharmacology, the characteristics of specific drugs, and the special physical, psychological and social needs of older patients.

In order to effectively treat bone and joint infections in the elderly, further research in this area must continue. The search for safe, easy and inexpensive means of rapid diagnosis and treatment should be a worthwhile target. Also, new antimicrobial regimens, antimicrobial agents or medications should be studied for their ability to promote healing, restore normal immune function, and safely eliminate infection without surgical intervention in older patients. Lastly, prevention of the disease through vaccines against the major responsible pathogens would also be a valuable goal of future research.

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