Infectious Arthritis and Wounds of Joints  (1-Jan-1985)

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- Septic Arthritis
- Open Joint Injuries
- Prognosis

Septic Arthritis

PATHOPHYSIOLOGY OF BACTERIAL INFECTION

Bacterial infections of joints usually begin suddenly and develop rapidly into an acute suppurative arthritis. Pain, lameness, and limitation of joint motion occur along with the classic signs of inflammation, swelling, redness, heat, and tenderness. Joint effusion is present early, thus providing a very important diagnostic tool. The patient usually manifests fever, although it may be low-grade. There is often a leukocytosis in the hemogram. Sterile aspiration of the joint will reveal an increased number of polymorphonuclear leukocytes, from 40,000/mm³ to 50,000/mm³ very early in the infection and rising rapidly to 100,000/mm³ or higher depending on the type of organism and the duration and severity of the infection. The synovial fluid glucose is usually reduced (in contrast to blood glucose) owing to its metabolism by massive numbers of polymorphonuclear leukocytes. In most joint infections the disease is monarticular, unlike some of the autoimmune diseases. (See Table 88-1.)

Suppurative arthritis due to hematogenous spread is most unusual in the dog and, when seen, is most often in the young or debilitated animal. Although many pathogenic bacteria have been incriminated in joint infections, the ones that most commonly attack these tissues are staphylococcus, hemolytic streptococcus, and Klebsiella spp from a pneumonic process. The infecting organism reaches the joint tissue (by hematogenous spread) as a result of a primary septicemia from a bacterial endocarditis, pneumonia, or abscess in another portion of the body. The most common entry is by a direct penetrating wound or a surgical wound. Sometimes the infection decompresses into the joint from metaphyseal bone infection.

The infection in the joint tissue manifests itself in a manner similar to infections elsewhere in the body. There is hyperemia with swelling and later edema of the synovial tissue. This is followed by an infiltration with inflammatory cells, principally polymorphonuclear leukocytes. Small vessels may rupture to produce petechial hemorrhages, and focal areas of necrosis may develop. A copious outpouring of fluid into the joint follows. This fluid is high in protein and has a lowered glucose content (Fig. 88-1). Fibrin and blood clotting mechanisms that do not inhabit the normal joint pour into the inflamed joint. Polymorphonuclear leukocytes are shed into the synovial fluid to produce purulence. As these polymorphonuclear leukocytes, in particular, and, to a lesser degree, the synovial cells phagocytize bacteria, they are broken down and their lysosomal enzymes, as well as other enzymes, are released into the synovial fluid. These enzymes attack and break down the cartilaginous matrix, leaving the collagen fibrils without support. The fibrin are then broken off mechanically, fragmented by the wear and tear of the joint motion in this abnormal situation. Replacement of the normal synovial fluid with the effusate, suppuration, and fibrin doubtlessly interferes with nutrient and cell waste transport mechanisms making the cartilage even more vulnerable to injury. Fibrin deposition can further impair the entrance of nutritional material into the cartilage from synovial fluid and may in fact further impede the release of metabolites from the cartilage. Fibrin itself can chemotactically attract leukocytes to the joint. Phagocytosis of this fibrin and other particulate matter by the leukocytes...
may result in leukocyte degeneration and release of more lysosomal enzymes. When the healing reaction is initiated, a mantle, or pannus, of granulation tissue forms from the synovial surface. It is composed of myriads of new vessels, which when spread over the articular plate cause further lysis by its penetration and undermining of the cartilage plate.

FIG. 88-1 (A) Photograph demonstrates obvious swelling of the left stifle in a 10-week-old Great Dane. (B.) Cranial-caudal and (c) medial-lateral radiographs of the same stifle demonstrate fluid distention and soft tissue swelling. The distal femoral and proximal tibial epiphyses appear very small owing to the dog's immaturity.

Even before this stage of infection has been attained within the joint, exudative inflammatory cells may be demonstrated in the subchondral cancellous tissue. It is believed by some authors that this is general and due to the association of the two sites by a common lymphatic system. (I) If the articular plate barrier is penetrated, there follows a frank suppurative osteomyelitis of the epiphysis (Fig. 88-2).

Today, because of the development of specific antibiotic agents and the early aggressive treatment, the complete course of suppurative arthritis is seen less often. This is fortunate because the articular plate has little or no capacity for regenerative healing. With the loss of articular plates, there is usually an extension of granulation from one subchondral area to the other across the joint space. As the granulation ages, it forms collagen scar tissue, and a fibrous ankylosis is the result. The collagen often calcifies as it condenses, followed usually by ossification/ankylosis. In short, if the joint infection progresses to destruction of the articular plate, joint destruction and patient crippling will be the result. It is imperative that the clinician make an early and accurate diagnosis so that the infection may be treated aggressively and curbed before irreversible joint damage takes place.

It cannot be emphasized enough that examination of the synovial fluid is probably the most valuable single means of making the correct diagnosis. The only early radiographic alteration may be a slight fluid distention of the joint (see Fig. 88-1); by the time the other joint alterations are visible radiographically, irreparable damage has been done (Fig. 88-3).

**DIAGNOSIS**

Diagnosis of the infection may at times be difficult. For example, in a series of 37 children treated at the Mayo Clinic, cultures of the synovial fluid of some with proven septic arthritis were negative. (10) Even so, a diagnosis of septic arthritis was made if any five of the following six clinical conditions were present:

- Low-grade fever
- Pain (localized to the joint) made worse by gentle, passive motion
- Swelling of the involved joint
- Systemic signs of lethargy, irritability, or "toxicity"
- No other demonstrable pathologic process, such as leukemia or intrapelvic abscess
- Satisfactory response to antibiotic therapy

In addition to meeting five of these six clinical conditions, the patient must have had a positive blood culture or two of the following three conditions:

- Pus aspirated from the joint
- Marked elevation of the erythrocyte sedimentation rate
Specific radiographic changes in the involved joint (hip)

Only one third of the children experiencing hematogenous spread had an elevated peripheral leukocyte count, while two thirds had only a shift to the left in the differential. A slightly widened joint space distended by the exudate may be the only early radiographic change. Late changes may include a persistent subluxation, destructive arthritis (similar to rheumatoid), and evidence of vascular compromise of the epiphysis in the young.

FIG. 88-3 Cranial-caudal radiograph of the stifle in a 6-month old Labrador retriever. Note the deep bony erosion of the lateral femoral condyle.

TREATMENT
The fundamental goals of treatment are listed below:

1. To clean the joint in order to avoid articular cartilage destruction and adhesion formation
2. To decompress the joint in the immature patient to avoid vascular embarrassment to the epiphysis
3. To administer adequate doses of antibiotics to eradicate the joint infection and prevent secondary spread

There is general agreement that a suppurative joint must be drained. However, to adequately debride the joint by multiple aspirations is difficult and possibly harmful to the joint because of repeated insults to the cartilage from the needle. (7) In the young animal, multiple aspirations are not likely to be adequate to prevent the accumulation of intra-articular debris and pressure. Whatever one's arguments for multiple aspirations as opposed to surgical drainage, this treatment has no place in the management of pyarthrosis of movable joints in the immature animal owing to the possibility of severe consequences if adequate decompression, as well as debridement, is not carried out early and rapidly.

TABLE 88-2 Broad-Spectrum Antibiotics

Broad-spectrum antibiotics are given immediately to maintain an around-the-clock blood level. Intravenous antibiotics are the first choice; intramuscular the alternate. The cephalosporins have been particularly effective in septic arthritis. Ampicillin has also been an effective drug. Penicillin in high doses and aminoglycosides have been used successfully. (11,13) (See Table 88-2.) These antibiotics are used until culture and sensitivity results are returned. The appropriate antibiotics should then be administered as frequently as possible for a minimum of 10 days.

Indications for Surgery
The indications for surgical management are as follows:

- Untreated suppurative arthritis of more than 72 hours duration
- An infected movable joint that has not responded to other forms of treatment (i.e., in the adult animal a totally unfavorable response to aspiration must have within the first 48 to 72 hours to prevent surgical intervention; this does not apply to movable joints in the young animal)
- Any penetrating wound to the joint
- A postoperative joint infection

Synovectomy is added to the following procedure when the synovium is found to be grossly necrotic as a result of the infectious process or the previous treatment. It should also be performed if the synovium is grossly thickened, impeding
Surgical Technique
The entire limb is prepared for surgery, and tourniquet hemostasis is used where possible. If anatomically feasible, bilateral incisions into the joint will give better postoperative drainage. The retinaculum, capsule, and synovium are opened in line with the skin incision. Careful attention must be paid to the synovium as it is incised. Exudation of pus anywhere along its cut edges indicates abscess formation and necessitates a subtotal synovectomy. At this point, samples of the pus and synovium should be taken for microbiological culture and drug sensitivity. Culture material can be centrifuged in an effort to improve the chances of a positive culture if large volumes of purulent material are found. The joint is irrigated thoroughly with copious quantities of saline or lactated Ringer's solution to remove all of the fibrin clots, foreign material, and loose fragments. The thorough inspection and removal of fibrin is an extremely important part of the procedure, since the fibrin will hold the infection. (5) Owing to difficulties of management and iatrogenic infection with suction-irrigation tubes following this surgical debridement, the wound is left entirely open on both sides. A fine mesh gauze is placed over the incision, followed by bulky absorptive dressing followed by bulky cotton dressing. In the more peripheral joints, bulky dressings can be removed after 24 hours and the mesh gauze changed by sterile technique and the incision covered by a looser bandage. In movable joints, an assisted range of motion is useful to aid in the egress of exudate. The range of motion should be done every day and a light dressing reapplied daily during the first week. The wound is allowed to close with the formation of granulation tissue and is not sutured or marsupialized. Occasionally it is necessary to employ saline irrigation during a bandage change, especially in the shoulder or hip where double incision drainage is not performed or where pockets of exudate may exist. The hemorrhagic effusion following synovectomy will require tube flushing for clot removal once a day during the first 3 days. Chemical debridement, antibiotic instillation, applications of drains and wicks, or attempts to close the wound early are not necessary in most instances. A 2-week program of parenteral antibiotics is the best and most aggressive antibiotic regimen; one week of parenteral antibiotics, followed by 1 to 3 weeks of oral antibiotics, is the alternative program. In extremely difficult cases, periodictultures of the exuding joint fluid can be taken.

#Aqua-flow, petrolatum gauze, Cheeseborough Ponds, Inc., Greenwich, CT

* Kerlix, fluffed gauze, Kendall Co., Boston, MA.

Open Joint Injuries
A penetrating joint wound has the potential to be a permanently disabling injury. Early and effective treatment may be relatively simple, but if septic arthritis develops, effective treatment is difficult. Open joint injuries can be the result of a vehicular accident, puncture wounds, or bullet wounds. Early diagnosis and treatment are of the utmost importance, although the patient's general condition and the type and severity of injury, as well as concomitant injuries, may dictate treatment. Nevertheless, when there has been delay in instituting the proper treatment, the presenting problem may be septic arthritis.

DIAGNOSIS
The diagnosis of a septic joint upon admission can at times be difficult. Temperatures may be elevated only slightly, if at all, and peripheral white blood cell counts may be likewise elevated only slightly, often presenting a stress-reaction hemogram and therefore being misleading. In one series, about 50% of synovial fluid cultures from proven septic joints were negative. (9) The patients in this series were treated with antibiotics, which probably accounts for the finding. More importantly, however, a synovial biopsy was a more reliable source of positive culture than surface swabs, culture of synovial fluid, or foreign bodies. (9) The presence and analysis of the effusion is a good diagnostic tool, since all penetrated joints will have an effusion (Table 88-1).

Thus the diagnosis of a penetrating joint injury can be based upon the following:

- Visible open laceration into the joint
- A palpable opening into the joint
- Air seen in the joint radiograph
- Extravasation of saline from the joint into the wound during arthrocentesis
- Extravasation of contrast media during arthrography, demonstrating a defect in the joint space.

TREATMENT
One must act as soon as the diagnosis of penetrating injury is made or suspected. Successful results are dependent upon early
diagnosis and surgical management. Penetrating joint injuries treated early by arthrotomy, debridement, and irrigation have a better prognosis than those treated several days later, since sepsis and potential irreparable damage may be avoided. A large incision and very thorough inspection are critical. The articular and periarticular tissues should be debrided carefully and thoroughly irrigated. Menisci, articular cartilage, bone stock, and ligaments should be preserved as much as possible. The articular cartilage not only forms a barrier to infection, but its continued good health is a primary goal of treatment.

The use of antibiotics is similar to their use in the treatment of septic arthritis. Broad-spectrum antibiotics are given immediately to maintain an around-the-clock blood level. Intravenous antibiotics are the first choice, intramuscular therapy alternate. The cephalosporins have been particularly effective in the open joint wound and in the open fracture. Ampicillin has also been an effective drug. Penicillin in high doses and kanamycin have both been used successfully (Table 88-2). These antibiotics are administered until culture and sensitivity results are returned. The appropriate antibiotic should then be administered as frequently as possible for a minimum of 10 days.

The patient is prepared for arthrotomy. In treating penetrating injuries, the surgical technique is critical. The animal should be draped to allow a full range of motion and to permit complete inspection of the joint. The tourniquet is used when possible to allow better vision. At surgery, cultures should be taken of the cartilaginous surface or more importantly still, a piece of the synovial tissue. All necrotic and contaminated tissue is debrided very carefully from the outside inwardly. Further damage to articular surfaces or condyles must be carefully avoided when extracting metal fragments, as in a gunshot wound. Small metal fragments left deep in the joint may not cause further damage or sepsis. Only evident or intraarticular pieces of metal are removed. The copious lavage is continued by means of gravity flow through an intravenous tubing setup, or a dental irrigating system (Surgi-Lav, Stryker Corporation, Kalamazoo, MI or Water-Pic) may be used. The large volume of irrigant fluid is important here. If after relatively early arthrotomy and irrigation the joint is clean and appears to have only viable tissue, the synovium and capsule are closed. Capsular sutures and soft tissue sutures of 3-0, occasionally 4-0, nylon are preferred. Polyglycolic acids (Dexo, Davis and Geck, American Cyanamid Co., Pearl River, NY) or polypropylene (Prolene, Ethicon, Inc., Somerville, NJ) may be used also.

The skin can be closed immediately or it can be closed 4 or 5 days later, a delayed primary closure if there appears to be periarticular contamination that cannot be removed by debridement. However, primary closure of the wound without the routine use of irrigation-suction tubes placed into the joint is the goal in most cases, regardless of whether debridement is being carried out within the 6 hour limit or, as is true in most cases, 10 to 12 hours later. In wounds with extensive soft tissue damage and loss of skin, contamination that cannot be debrided completely, or an effusion indicating sepsis, a decision must be made either to close the wound with irrigation tubes in place or, as preferable in most instances, to leave the entire wound open. If a well-debrided wound with extensive soft tissue loss has been closed for some unusual reason, treatment must be initiated promptly should infection appear or the tube system becomes clogged.

Suction-irrigation tubes used in the joint are difficult to manage and often ineffective. It should be noted that their use carries a substantial risk of introducing pathogenic organisms into a joint not already infected. Furthermore, the iatrogenic contamination may involve gram-negative organisms, and infection with these organisms, notably Pseudomonas, Klebsiella, and other bacillary rods, may be quite difficult to eradicate. Therefore, if a tube system is used at all, it is best to use it with conscientious nursing care and probably for a short period of 1 to 4 days.

Open abrasion injuries in which the tarsus or carpus has been sheared by dragging on the concrete are treated by debriding only dead tissue, with care taken to curette the ground-in dirt and to provide a copious lavage. Culturing this wound is optional, since the wound is packed open. There are two reasons that shearing injuries should rarely, if ever, be closed: The dirt is often ground into the bone and thus is difficult to remove. Also, the ligamentous and capsular structures that have been ground away will need the large bed of granulation tissue that forms postoperatively and later is converted to scar tissue, thereby providing stabilization for the joint. If skin closure is done early, no granular bed appears. Therefore, the ultimate stability of this abraded joint is far less than it would be if the granular bed were allowed to form and subsequently contract.

**POSTOPERATIVE MANAGEMENT**

Identification of contaminating microorganisms and their sensitivities is obviously important in the postoperative management of the penetrating joint injury that has been closed primarily. If frank sepsis is present, a bilateral incision, if anatomically feasible, is probably desirable to drain the joint. The value of beginning antibiotics preoperatively has been established. The penetration of antibiotics into normal and inflamed synovium has also been demonstrated.

Postoperative febrile episodes may indicate the necessity for reexploration, redebridement, and reculture. It is most important to identify the organism and its antibioticsensitivity both intraoperatively and for any postoperative infections.
The synovium should be left open in those joints that appear to be septic upon presentation. If there is purulence with a thick, gray, hypertrophic synovium, the synovium should be removed. When accumulation or drainage of synovial fluid has ceased, the delayed skin closure can be performed, often 4 to 5 days after injury. The synovium usually closes itself off in a day or two and does not require closure by itself. If there is an increase in synovial fluid, the synovium will remain open and allow drainage. In the wound that is left open, petrolatum gauze is used to allow blood and synovial fluid to drain freely into fluff gauze. Telfa and wet dressings do not allow free drainage. Immobilization is accomplished with a cotton compressive (Robert Jones type) dressing, which will prevent edema of the extremity and accumulation of intra-articular fluid. If for some reason the arthrotomy cannot be performed immediately, aspiration and lavage with a large-bore needle are necessary to prevent the accumulation of fluid, white cells, and debris, which prevent the proper functioning of antibiotics. The injection of antibiotics into these joints is usually not recommended, since it may lead to a troublesome synovitis. The joint is allowed minor passive motion the first week, and after another 1 to 2 weeks mobilization of the joint is allowed.

**FRACTURE FIXATION**

Open fractures of a joint can be treated as follows: if the arthrotomy is performed early, preferably within 6 hours, and the amount of soft tissue damage is minimal, a displaced fracture, such as a condylar fracture, can be fixed with rigid internal fixation, such as an interfragmentary lag screw fixation. Apophysial fractures should be fixed with tension band wiring. If there is a possibility of sepsis in the joint, internal fixation can be delayed from 5 to 10 days until the infection is under control. If collateral ligaments are ground away, on the fifth to eighth day screws may be placed at the origin and insertion of the collateral ligament to anchor a figure-of-eight wire or Prolene (1-0, 2-0) temporary prosthesis to increase stability and maximize range of motion. Much of the wound may still be left open. These fixation devices are removed in approximately 6 weeks.

**Prognosis**

Delay in diagnosis and treatment appears to be the important factor affecting prognosis; however, other determining factors may be the organism involved, the adequacy of treatment, and the presence or absence of metaphyseal osteomyelitis and/or penetrating joint wounds, in which much of the cartilage and bone stock has been violated. The advantages of arthrotomy are that a complete decompression, thorough debridement, and irrigation of the joint may be performed. There is also a better chance of a definitive diagnosis (positive bacteriologic culture). A practical treatment that allows the joint to remain open has been described. Motion, rather than immobilization, can be employed to express quantities of exudate from the wound. In this method, the prolonged exposure of articular cartilage in the wound has caused some concern. However, this exposure does not appear to be detrimental. Many antibiotics can pass the inflamed synovial membrane and reach comparable blood levels. The broad-spectrum antibiotics in Table 88-1 are used until culture results can be obtained.

For our rationale we recount the pathophysiology. The first measurable event in the degradation of cartilage in septic arthritis is the depletion of matrix. A number of enzymes are capable of breaking down the matrix: lysosomal enzymes (released from cartilage, neutrophils, or synovium); plasmin (plasminogen activated by staphylokinase); and extracellular proteolytic enzymes produced by *Staphylococcus aureus*. After 4 days of infection there has been loss of matrix but not of collagen. After this period of time, the loss of collagen ensues. The destruction of the cartilage proceeds not only from the interference with nutrition but also from the destructive enzymes in the septic joint fluid. The rationale for Savage, therefore, is that it removes cartilage-destroying enzymes as well as bacteria, bacterial products, and fibrin deposits covering the articular cartilage.

In humans, aseptic arthritis that has been successfully treated by antibiotics is frequently followed several weeks later by an obesaceous acute inflammatory synovitis. The joint continues to be inflamed for many months and, much like a rheumatoid joint, often undergoes progressive destruction with loss of articular cartilage. There is evidence that part of this secondary phase of septic arthritis is associated with an immunologic disease of the articular cartilage initiated by the septic process.

**References**

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