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Infections in arthroscopy

G. SIRCANA[1,2], M. PASSIATORE[1,2], L. CAPASSO[1,2], M.F. SACCOMANNO[1,2], G. MACCAURO[1,2]

[1]UOC Ortopedia e Traumatologia, Dipartimento di Geriatria, Neuroscienze ed Ortopedia, Fondazione Policlinico Universitario A. Gemelli IRCCS, Rome, Italy
[2]Istituto di Clinica Ortopedica e Traumatologica, Università Cattolica del Sacro Cuore, Rome, Italy

Abstract. Infection is a rare complication of arthroscopic procedures, with an overall incidence estimated in less than 1%. However, the actual prevalence may be higher as many cases may go unreported. Despite low incidence, early diagnosis is of outmost importance in order to avoid devastating consequences, such as arthrofibrosis. Clinical presentation is usually not specific and may include, at varying degrees of severity: increasing pain and stiffness, local erythema, swelling, warmth, and fibrinous exudate. High temperature and signs of sepsis are not common but may be present in severe cases. Unfortunately, variable clinical presentation coupled with a low index of suspicion may result in delayed diagnosis. Several risk factors have been identified, mainly related to the surgical site, patient characteristics or the surgical procedure. The aim of this paper is to provide an overview on pathogenesis, risk factors, clinical presentation, diagnostic evaluation, and current treatment options of septic arthritis after an arthroscopic procedure. Since no relevant data are available on infections after hip, ankle or elbow arthroscopy, the present review is mainly focused on infections after shoulder and knee arthroscopic procedures.

Key Words
Septic arthritis, Shoulder, Knee, Postoperative infection, Arthroscopy.

Introduction

A large number of arthroscopic procedures are performed in the world every year. Arthroscopy is considered an efficient procedure, and its popularity is increasing. Infection is a rare complication of arthroscopic procedures, with its overall incidence estimated in less than 1% of procedures[1]. Being an uncommon event, diagnostic and management strategies are not well established. On the other hand, being arthroscopic surgery so widespread, its complications have started to raise interest: infection accounts for 37.14% of re-hospitalizations after arthroscopic surgery[2]. Septic arthritis has to be considered an emergency: a delay in its diagnosis and, consequently, treatment may hinder a successful treatment and the achievement of good functional results. In scientific literature, various studies debated on incidence, risk factors and outcome of infection after knee and shoulder arthroscopy. Less prolific are the data on hip, elbow, and ankle. The incidence of post-arthroscopic infection has been estimated at 0.5% in hip surgery[1], whereas administration of intra-articular injections 3 months before the surgery has been claimed as an important risk factor[3]. Infections after ankle or elbow arthroscopy have been reported as high as 0.16-0.6%[1] and 1.55%[4], respectively. Furthermore, a corticosteroid injection concomitant to surgery has been held responsible for an increase in infection cases[4,5]. Taking into consideration the paucity of data regarding hip, elbow and ankle arthroscopy, the aim of the present review is to provide an overview on incidence, diagnosis and treatment of infections after shoulder and knee arthroscopy.

Shoulder Arthroscopy

It has been reported that more than 500,000 shoulder arthroscopies are performed every year in the US[6], and half of these procedures are rotator cuff repairs[6]. Shoulder arthroscopy is a safe procedure, having an overall complication rate between 0.99% and 10.6%[7,8]. Infection after shoulder arthroscopy is a rare complication that needs early diagnosis and appropriate treatment.

Epidemiology

In large series, the rate of infection after shoulder arthroscopy has been reported to range between 0.16% and 0.85%[9-13]. The advent of arthroscopic techniques brought a significant reduction in infection rates if compared to open shoulder surgery[14]. Among the different arthroscopic

Corresponding Author: Giuseppe Sircana, MD; e-mail: maristellafsaccomanno@gmail.com

procedures, rotator cuff repair has shown the highest infection rate, while Bankart repairs the lowest[10,11]. Arthroscopic revision surgery, involving higher complexity procedures, carries an infection rate of 2.1%[15].

The most common pathogens associated with shoulder infection after shoulder arthroscopy are *P. acnes* and *Staphylococci*[9,13,16-18]*:* they are the most common isolates in sebaceous areas of the skin and account for nearly all infection cases. Some other pathogens have been found responsible for shoulder infections: *P. aeruginosa*, *M. tuberculosis*, *Actinomyces* species[9,19,20].

Risk factors can be divided in surgical site related, patient related and surgery related.

Shoulder and axilla have a large number of hair follicles and sebaceous glands, providing a good habitat for *P. acnes* and Coagulase Negative *Staphylococci*[9,21]. In recent years, great interest has risen on *P. acnes*. This microorganism is a commensal, Gram-positive, facultative anaerobic, non spore-forming rod that is a major colonizer and inhabitant of the human skin. It has the ability to form a biofilm, thus being able to adhere on implants and hardware[22]. A superficial skin colonization at the arthroscopic portal sites by *P. acnes* has been found in 47.7-72.5% of patients before skin disinfection[23,24]. Colonization is more frequent in male (81.6%) than female (46.1%) patients[23-25]. Clipping of the axilla does not decrease the *P. acnes* burden and, surprisingly, increases the total bacterial burden of the area[26]. Moreover, the best modality for skin disinfection is still under debate. Saltzman et al[27] compared the rate of surgical site colonization prior and after disinfection. Cultures, obtained by skin swabs, show a persistence of colonization of 31% after povidone-iodine disinfection, of 19% after iodophor-isopropyl alcohol disinfection and 7% after chlorhexidine-isopropyl alcohol disinfection[27]. Sethi et al[25] found that, after surgical disinfection, *P. acnes* could still be cultivated from skin swabs in 22.8% of patient, and, at the end of the surgical procedure, this rate would rise to 42.6%. In a recent study, in which biopsies of the derma were cultured, no difference in terms of *P. acnes* colonization could be found after disinfection with chlorhexidine compared with controls[28]. In a prospective study[29] of patients undergoing primary shoulder arthroscopy, the application of benzoyl peroxide on the surgical site for at least two days before surgery decreased *P. acnes* colonization rate before skin preparation to 16%. In another series, adding clindamycin phosphate to benzoyl peroxide, the colonization rate decreased of 78.9% after at least two applications[24]. Chuang et al[23], in a prospective study of 51 patients undergoing shoulder arthroscopy, collecting deep tissue samples at the end of the procedure, found a *P. acnes* colonization in 19.6% of patients. In another series, after preoperative application of benzoyl peroxide and clindamycin phosphate, the deep tissue colonization rate decreased to 3.1%[24]. Namdari et al[30], after administration of a 7 days course of doxycycline to patients undergoing shoulder arthroscopy, found no difference in culturing outcome compared to controls; taking biopsies at the arthroscopic portals, cultures were positive for *P. acnes* in 51.3% of patients after surgical disinfection. In a series of 57 primary arthroscopies, up to 31.6% of deep intraoperative specimens were positive for *P. acnes*[25]. Furthermore, Patzer et al[31] reported that cultures are more frequently positive in gleno-humeral space than in subacromial space and found a correlation between cutaneous positivity and deep tissue positivity. Yamakado et al[32] evaluated the colonization of sutures with different types of skin preparation in a randomized study of 125 patients: when the skin was prepared with povidone-iodine, 47% of cultures were positive for *P. acnes*; when a plastic sterile drape was added, colonization decreased to 33% of patients; when disinfection was performed with chlorhexidine-alcohol, colonization was found in 33% of patients; this rate decreased to 9.3% when a sterile drape was added. Eventually, it was noted that, with the sterile drape, in 3-6% of cases a Coagulase-negative *Staphylococcus* was isolated[32].

Among patient related risk factors, obesity[33], male sex[13,34], and older age[9,11] have been found to increase the risk of infection. Werner et al[35], in a revision of a large database of patient records, reported that performing shoulder injections in the 3 months before surgery increases the risk of shoulder infection of 2.2 times, and even performing one injection in the 6 months previous to surgery increase the risk of 1.6 times.

Surgical timing has a great impact on postoperative infections: a shorter surgical duration is protective of infections[12,25]; the risk of infection in surgery lasting more than 45 minutes increases of 3.63 times, rising up to 4.40 times if surgery lasts more than 90 minutes[12]. Antibiotic prophylaxis is another key point in infection control: it is able to decrease the infection rate from 0.58% to 0.095%[10] or from 1.54% to 0.28%[9] according to different authors. The administration of antibiotic prophylaxis has even changed the most common

isolated pathogens: in a large series, a marked decrease in *Staphylococci* isolation has been registered and, as a result, a relative increase in *P. acnes* isolation, being this pathogen scarcely influenced by standard antibiotic prophylaxis[9].

Diagnosis

The most common symptom of shoulder infection is shoulder pain. Based on a large case series evaluating 3294 arthroscopic rotator cuff repairs, patients presenting with signs of infection showed local signs, such as redness and swelling, in 67.9% of cases, while secretion from the wound occurred in 50% of them and fever only in 32%[9]. Moreover, infections sustained by *P. acnes* became clinically evident later than infections caused by other pathogens[9].

A diagnostic laboratory workup should include a white blood cell count, an erythrocyte sedimentation rate (ERS) and dosage of C reactive protein (CRP)[36]. In a series of 39 cases of infection after rotator cuff repair, white blood cells count was increased in 12% of cases, ERS in 60% and CRP in 50% of cases[21]. No difference has been reported in the laboratory evidence between infections sustained by *P. acnes* and by other microorganisms[9].

Gleno-humeral joint aspiration is another analysis that should be performed. White blood cell count and microbiological cultures should be performed on the sample obtained[36].

Radiographic evaluation is rarely necessary and often negative, at least in acute cases. MRI could help in identifying complications such as abscesses or osteomyelitis[36].

In selected cases, when clinical suspicion is high, but laboratory findings remain negative, an indium 111-labeled white blood cell count might be considered[36].

Treatment

Treatment of early, superficial infections could rely on antibiotic administration[10]. Deeper and later infections usually require surgical debridement[36]. It is important to discontinue any antibiotic treatment five to seven days before surgical debridement: during surgery, specimens must be obtained and cultured in order to obtain or confirm an aetiological diagnosis and perform a targeted antibiotic treatment[36].

Surgical debridement could be either open or arthroscopic, and it can be associated with hardware removal[8,9,13]. Sometimes, a single debridement is inadequate and reoperations are needed[9]. Unfortunately, to our knowledge, no treatment algorithms have been proposed to guide the therapeutic choice in terms of the extent of debridement and hardware management.

Outcomes

Only two studies reported outcomes of treatment of infection after shoulder arthroscopy.

Athwal et al[21], in a series of 39 cases of deep shoulder infections treated with surgical debridement and antibiotic therapy, at a mean follow-up of 8.2 years, reported successful treatment of all cases of infection and good results in terms of pain and functional scores, despite a range of motion restriction. Kwon et al[37] reported the results of 12 cases of debridement after early post-operative deep shoulder infection: at 37.5 months follow-up, mean UCLA score was 23.6 and good results were achieved in terms of pain, while a range of motion restriction persisted.

Knee Arthroscopy

Knee arthroscopy is a very common procedure. The main indications are meniscal or chondral lesions as well as anterior or posterior cruciate ligament reconstructions, or intra-articular loose bodies removal.

Epidemiology

The incidence of septic arthritis as an acute complication after knee arthroscopy is very low[38,39].

Risk factors can be divided into two categories: surgery related and patient related.

Most of the available data on infections after knee arthroscopy actually rely on anterior cruciate ligament reconstructions (ACLR) probably because it requires a longer surgical time (compared to an arthroscopic meniscectomy) and autografts or allografts are needed. Moreover, the possible association with other complex intra and/or extra-articular procedures can even lengthen the surgical timing. The infection rate after ACLR range between 0.3%-2.25%[40-42].

Recently, Clement et al[38] analyzed an administrative US healthcare database containing data of 526,537 patients who underwent 595,083 arthroscopic knee procedures. Data showed that deep postoperative infections occurred at a rate of 0.22%, whereas superficial infections occurred at a rate of 0.29%. Furthermore, the authors concluded that tobacco use and obesity were the main

risk factors for deep and superficial infection ($p < 0.001$; relative risk of 1.90 and 2.19, respectively). High-complexity arthroscopies, male sex, diabetes, younger age, and an increased Charlson Comorbidity Index score were also associated to a higher risk of postoperative infection[38].

Moreover, prior surgery[39], type of graft[43,44], type of fixation[40], and associated procedures (i.e., meniscal repair)[38], have been also claimed as risk factors.

About the type of graft, Judd et al[44] reviewed 1615 consecutive ACLRs performed within 7 years using autograft bone-patellar tendon-bone (BPTB) or hamstrings. They found that all cases of infection occurred with hamstring autografts.

A recent meta-analysis showed that, although the overall infection rate after ACLR is relatively low, it is quite higher when hamstring (auto or allografts) are used, compared with bone-patellar tendon-bone (BPTB) autografts[45]. Interestingly, a retrospective comparative study highlighted that there is no difference between hamstrings and BPTP; it found that, in case of relatively short hamstring grafts, suture material could protrude inside the knee joint, acting as a foreign body and stimulating the formation of a fibrinous coat adherent to the graft. As a result, a synovitic reaction can be promoted with consequent effusion, that has been reported as a risk factor for infection[46]. On the opposite, Fong et al[47] postulated that in ACLR infection spreads from the tibial tunnel end (extraarticular) to the knee joint (intraarticular), so that the infection could have originated from hematoma collection in the pretibial subcutaneous tissue.

Moreover, although it is a common opinion that allografts could be a source of infection[48], recently a large cohort study including more than 10 thousand cases showed that, at 90 days follow up, the incidence of deep infections after ACLR by using allografts was very low (0.15%), even if the grafts were not processed[49].

Whether the use of a drain can be a source of infection is still a matter of debate[50,51].

The most common pathogens associated with knee infections are *Staphylococcus aureu*s, Coagulase-negative Stafilococci (CNS), such as *Staphylococcus epidermidis,* and other coagulase-negative species[47,52-56]. Methicillin-resistant *Staphylococcus aureus (MRSA)*, anaerobic microorganisms[41,57,58], *M. tuberculosis*[42,59], atypical *mycobacteria*[60], *Brucella*[61], *Helicobacter*[62], fungal infection[42,63] have also been reported.

Recent systematic reviews on management of septic arthritis after ACLR, showed that 75% of cases had positive culture, with 45.6% positive for CNS and 23.8% positive for *S. aureus* and 21.1% positive for *Genus Streptococcus* (including *Peptostreptococcus* and *Enterococcus*), *Enterobacter, Escherichia coli, Pseudomonas aeruginosa, Propionibacteriaceae, Corynebacterium* and *Klebsiella*. Although less common, *S. aureus* is more virulent than CNS, and therefore the prognosis is poorer[39,42].

Diagnosis

Early diagnosis is crucial. Unfortunately, initial clinical features are usually masked by common post-operative symptoms[64].

From a histological standpoint, hyperplasia of the lining cells in the synovial membrane can occur within 7 days. Since synovial tissue has no limiting basal membrane, bacterial organisms can easily enter the synovial fluid, and cytokines and proteases cause an irreversible chondral damage and inhibit the synthesis of cartilage[64]. Irreversible histopathological modifications, such as fibrosis, can occur even if clinical signs are missing or are not immediately clear, and that could last after the early treatment[65,66].

From a clinical standpoint, the diagnosis could be delayed up to 2 or 3 months after the arthroscopic procedure[39,47]. Signs of subacute septic arthritis may appear as late as 2 weeks after ACLR[40,56]. Long-lasting pain with no sign of improvement could be suggestive of septic arthritis[39,67].

Moreover, erythema can be evident in the area of the surgical wounds; pus leaking could be also encountered[68].

Non-specific systemic symptoms, ranging from fever to acute shock, have also been reported[68].

Joint aspiration and subsequent synovial fluid analysis are the mainstay of diagnosis[39-41,47,68]. Paci et al[69] showed that a white blood cells count >16,200 g/mm^3 could be considered the threshold for infection after ACLR with a sensitivity of 86% and a specificity of 92%. Microbiological cultures, when positive, are of outmost importance for a tailored antibiotic therapy.

After arthrocentesis, empirical antibiotic therapy can be immediately started[40,41,57,64].

Multiplex polymerase chain reaction (PCR) is an emerging technology that has been successfully used in the last years to rapidly identify Gram-positive pathogens and detect resis-

tant organism too[70]. Some preliminary data for Gram-negative pathogen identification are already available, although clinical experience is overall limited[71,72].

Some reliable kits can identify up to 24 different bacterial and fungal species and common antimicrobial resistance genes within the first hour of organism growth in blood sample[73]. A few data are available about its application to synovial fluid[70,74].

Laboratory exams could be useful but are not specific. As a matter of fact, ESR or CRP are expected to be elevated in the post-operative period[40,64]. Conversely, a suspicion for infection is mandatory if ESR and CRP values do not decrease or even increase in 2-3 weeks after the procedure[40,65,75].

Imaging does not have a role in the diagnosis, but it could be useful in the follow up[76,77]. Arthroscopic lavage can be diagnostic and therapeutic at the same time[41,78].

Treatment

If septic arthritis is strongly suspected, empirical antibiotic therapy is usually started. Intraarticular antibiotics are not recommended[79]. A specific antibiotic therapy can be started only after running microbiological tests on synovial fluid[80]. Based on the American Infectious Diseases Society recommendations, vancomycin from 15 up to 20 mg/kg/dose every 8 to 12 hours should be administered in case of Gram-positive infections. It could be replaced by an adequate dose of cefazolin, nafcillin, oxacillin in case of MSSA, or replaced by daptomycin, linezolid or clindamycin in case of MRSA, when Vancomycin is not tolerated[79]. Ceftriaxone (2 g once daily), cefotaxime (2 g every 8 hours) or ceftazidime (1 to 2 g every 8 hours) should be administered in case of Gram-negative infections. In case of penicillin allergy, aztreonam (2 g every 8 hours) or gentamicin (3 to 5 mg/kg per day in two to three divided doses) could be administered[80].

Duration of treatment can vary, but usually it does last at least 4-6 weeks[39,79,81,82].

Although real guidelines are not available, arthroscopic debridement is sometimes recommended[40,41,83]. Torres-Claramunt et al[41] recently proposed an algorithm based on clinical suspicion supported by positive laboratory exams (joint aspirate, blood cell count and CRP). The authors suggested multiple arthroscopic debridements if laboratory test doesn't improve in 72 hours after the first debridement. Moreover, ACL graft removal should be considered if more than three debridements have already been performed. On the contrary, if clinical suspect is not substantiated by laboratory exams, clinical observation for 48-72 hours is recommended before repeating laboratory exams (joint aspirate, blood cell count and CRP)[41].

According to Mouzopoulos et al[40], ACL graft should be removed only if it is mechanically nonfunctional or if it impregnated by a tenacious, thick purulent exudation that cannot be shaved without damaging it, or when a *S. aureus* infection has been proved.

Some authors also recommended open debridement in case of fungal[84] or persistent infections[85].

Finally, as a preventive strategy, graft presoaking with vancomycin in combination with classical intravenous antibiotic prophylaxis has been recently proposed to reduce the rate of knee joint infections following an ACLR[41,86-88]. However, further studies are needed.

Outcomes

Outcomes basically rely on early diagnosis and appropriate treatment[42] as well as identification of the pathogen[39].

Only few case series are available, and all studies showed reduced functional performance at short and long follow-up when compared to uncomplicated cases[44,47,57,89,90].

Future Perspectives

Infection after arthroscopic procedures is a rare complication which might lead to a severe disease with a poor functional prognosis[91]. Early symptoms of infection can be easily misinterpreted as normal post-operative complaints. Unfortunately, up to now, although several treatment strategies have been proposed, a clear and shared diagnostic-therapeutic algorithm has not been provided yet. It has been proved that the prophylactic use of antibiotics is efficient in the prevention of post-arthroscopic infections[9,10]. However, there are no purposely designed studies to investigate the specific class and dosage of antibiotic to maximize the prophylactic effect. Therefore, considering the increasing numbers of arthroscopic surgeries, the development of guidelines on prevention as well as early diagnosis and management of infections will be of outmost importance.

Conclusions

Infection post-arthroscopic surgery is a rare complication, though its frequency is increasing as the number of arthroscopic procedures increases. The administration of antibiotic prophylaxis should be considered a mandatory step in order to decrease the rate of postoperative infections. Clinical presentation of this complication might be not evident, thus requiring a watchful monitoring of patients in their post-operative convalescence.

Conflict of Interests

The authors declare that they have no conflict of interest.

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