ABSTRACT

Joint aspiration is a reliable tool for diagnosis of periprosthetic infection. There are different indications, techniques, and approaches for joint aspiration. We recommend that it be performed selectively when infection is suspected clinically. The specimens should be interpreted based on the results of the culture as well as the white cell count and differential. Specimen collection, transport, and analysis should be prompt to ensure yield accuracy.

Key words: arthroplasty; hip joint; knee joint; prosthesis-related infections

INTRODUCTION

Diagnosis of infected total joint arthroplasty is difficult, as no single test achieves high sensitivity and specificity. A good history taking, physical examination, and evaluation of serial radiographs are important. Inflammatory markers, nuclear imaging, and joint aspiration are necessary to confirm the clinical suspicion of infection. Joint aspiration enables determination of the causative microorganisms and their sensitivity to antimicrobials. This article reviewed indications for joint aspiration, its different techniques and approaches, and interpretation of the results.

INDICATIONS FOR JOINT ASPIRATION

Routine joint aspiration to confirm infection before having revision surgery is recommended. Nonetheless, joint aspiration is an invasive procedure and may cause complications. Four complications were reported in a series of 78 hip arthrographs. One patient developed a femoral nerve palsy secondary to bleeding in the femoral sheath, 2 had mild groin pain, and one had increased pain secondary to a loose femoral component. In a series of 291 hip aspirations, 3 patients were hospitalised for painful synovitis, and one acquired an infection after undergoing combined aspiration and arthrography. False positive and false
negative results also complicate decisions pertaining to the diagnosis of periprosthetic joint infections. The incidence of periprosthetic joint infection in the test cohort affects the positive and negative predictive values of the test. Routine joint aspiration in patients at low risk of infection decreases the positive predictive values.

Therefore, selective joint aspiration is suggested when infection is suspected clinically. According to the American Academy of Orthopedic Surgeons, the decision of joint aspiration should take into account the probability of periprosthetic joint infection and whether any revision surgery is planned. Determination of the C-reactive protein (CRP) level and erythrocyte sedimentation rate (ESR) are sensitive means of detecting infection. Infection is unlikely if ESR and CRP level are normal (negative likelihood ratio, 0–0.06). When either one is positive, further investigations are warranted.

INDICATIONS FOR REPEAT ASPIRATION

Repeat aspiration is indicated if a false negative or false positive result is suspected based on the presence of clinical or radiographic evidence of infection (high ESR or early appearance of a complete radiolucent line). Repeat aspiration is also indicated when a positive culture is based on liquid media only in the absence of any other evidence of infection. Combining the result of initial and repeat aspiration, sensitivity is reported to be 100%.

TECHNIQUES

Aseptic precaution (proper skin preparation, draping of the patient and the fluoroscopic equipment, in a dedicated room for clean procedure only) should be observed. Joint aspiration is usually performed in a day-case setting in a radiology department or operation theatre. The false positive rate is similar in the 2 settings (17% vs. 22%). Joint aspiration in the radiology department is less costly and enables simultaneous arthrography if indicated.

Fluoroscopy can be used to guide hip aspiration. Hip aspiration using anatomic landmarks alone is not reliable and may cause injury to the femoral nerve. Computed tomography–guided aspiration is indicated in cases with heterotopic bones blocking the path of needle entry. Ultrasonography-guided hip aspiration in patients with total hip replacement can decrease fluoroscopic exposure and the radiation dose, and demonstrate any effusion.

For patients with central superomedial migration of the femoral head, the superolateral approach to the hip joint can bypass the bowel or bone anterior to the femoral head. It is also useful for patients with superior migration of the greater trochanter in whom the lateral approach is not possible. A modified technique was reported to achieve a lower dry tap rate of 2.2%. For this, the needle is advanced past the superolateral aspect of the neck of the prosthesis into the dependent portion of the joint under fluoroscopic guidance. Contact of the needle tip on the metal prosthesis confirms correct positioning. Intra-articular placement can also be confirmed by contrast arthrography.

Local anaesthetics (lidocaine and procaine) inhibit the macromolecular synthetic pathway in bacteria in vitro; the bacteriostatic property of local anaesthetics may therefore decrease the yield.

DRY ASPIRATION

In 77 patients with total hip arthroplasty undergoing joint aspiration, 23 (32%) had dry or inadequate joint aspirates initially. The mean volume aspirated was 4.1 ml in infected and 4.7 ml in non-infected prosthesis. Repositioning the needle deep to the inferomedial aspect of the femoral neck under fluoroscopic control is suggested if no fluid is aspirated. Injection of 10 ml normal saline and then repeating the aspiration is also suggested, although in some cases no fluid can be aspirated even after saline injection. The sensitivity of the culture from hip aspiration with saline injection is comparable to that without saline injection (83% vs. 82%). Slow manipulation (repeated flexion, internal rotation combined with adduction) of the hip while the needle was in place helps obtain an adequate amount of fluid.

EFFECT OF PREVIOUS ANTIBIOTICS

The yield from joint aspiration is affected if patients receive or have received antibiotics. The sensitivity of joint aspiration is lower in patients receiving antibiotics than not (41.6% vs. 75%). The odds of having a culture negative specimen increase 4.7 fold if the patient has received antibiotics within the last 3 months.

To increase the sensitivity of the culture result, a minimum of 2 weeks after stopping of antibiotics is recommended before joint aspiration. The sensitivity of periprosthetic tissue culture is 60.8%
if patients have not received antibiotics within 14 days of surgery, and decreased to 45% if received. Nonetheless, if sonicate fluid culture is used, such a difference is not evident. When the sonicate fluid is put into the culture after the explanted prosthesis undergoing bath sonication to dislodge the adherent bacteria, the sensitivity in patients who have and have not received antibiotics in the previous 2 weeks is 75% and 78.5%, respectively.23

SYNOVIAL FLUID CELL COUNT AND NEUTROPHIL PERCENTAGE

The synovial fluid white cell count and the neutrophil percentage can be used to determine the likelihood of infection. A lower cut-off is used for periprosthetic joints as compared to native joints, because of the lower virulence of microorganism in periprosthetic joint infection and its biofilm characteristics. Cut-off values of 1100/μL, 1700/μL, and 3000/μL have been reported for the synovial fluid white cell count and 64% to 65% for the neutrophil percentage.24–26 The sensitivity and specificity of synovial fluid white cell count have been 91 to 100% and 88 to 98%, respectively, and the corresponding values of neutrophil percentage have been 95 to 98% and 85 to 98%.24–26 The median synovial fluid white cell count is 18 900/μL in infected arthroplasty and 300/μL in non-infected arthroplasty.24

In the early postoperative period, a higher cut-off is used because of the haemathrosis and postoperative inflammation. A synovial fluid white cell count of 27 000/μL gives a sensitivity of 84% and specificity of 99% for infected total knee replacement during the first 6 weeks. Using 89% as a cut-off for neutrophil percentage, the sensitivity is 84% and specificity is 69%.27

Analysis of synovial fluid white cell count should take into account of the presence of traumatic tap, the time interval between specimen collection and analysis, the storage medium, and the storage environment. If joint aspirate contains blood-stained colour, synovial fluid white cell count may not be accurate, as white cells from the circulation are included. A formula can be used to adjust for synovial white cell count in the event of traumatic tap.28

Joint aspirate specimen should be examined promptly, as synovial white cell count decreases with time. Over a 6-hour period, synovial white cell count decreases by 41 to 64%. In mildly or moderately inflamed samples, white cell count can decrease to non-inflammatory range.29 Synovial fluid should be stored in tubes containing ethylenediaminetetraacetic acid (EDTA) and kept the specimen at 4°C before analysis.30 Synovial fluid white cell count decreases by 47% after 48 hours when stored in heparin, compared with 5.1% when stored in EDTA. EDTA is a much more suitable preservative than heparin.

Synovial fluid white cell count should be interpreted carefully in patients with crystal-induced arthritis. False positive results in crystal-induced arthritis has been reported.31,32 The sensitivities, specificities, negative predictive values, and positive predictive values of the tests are comparable in patients with inflammatory arthritis and non-inflammatory arthritis. The optimal cut-offs for inflammatory and non-inflammatory arthritis are 3500/μL and 3400/μL for synovial fluid white cell count, and 88.5% and 85.1% for neutrophil percentage.

<p>| Table | Culture of joint aspiration in diagnosis of periprosthetic joint infection |</p>
<table>
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<th>Study</th>
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<th>No. of aspiration</th>
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<td>Fehring and Cohen4</td>
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<tr>
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<td>Routine</td>
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<td>72.5</td>
<td>95.2</td>
<td>85.3</td>
</tr>
</tbody>
</table>

* Presence of one or more of the following features: clinical or radiological suspicion of infection, erythrocyte sedimentation rate of >30 mm/h and C-reactive protein of >10 mg/l, presence of any disorder that can raise inflammatory markers, a history of wound infection, implant failure less than 5 years after arthroplasty
respective.33

CULTURE OF JOINT ASPIRATION

Gram staining has a low sensitivity of 10 to 67%.1,5 The sensitivity and specificity for culture of hip or knee aspirate range from 50 to 86% and 88 to 96.1%, respectively (Table).1,4,6,8,20,34,35 To increase the yield of the joint aspirate, specimen should be sent for analysis immediately.36 Prolonged culture for 2 weeks can identify periprosthetic infection that would otherwise remain undetected. The microorganisms detected in the second week include Propionibacterium species, aerobic gram-positive bacilli, and Peptostreptococcus species.37 Culture medium may also affect the sensitivity. In 47 cases of bacterial arthritis, 33 use the blood culture procedure in addition to the conventional method; 23 specimens are positive in both methods and 10 are positive in the blood culture procedure only.38 The advantages of using blood culture bottle to inoculate joint aspirate include detection of fastidious or slow growing organisms,39 ability to detect more pathogens and fewer contaminants,40 and improvement in the sensitivity for detecting microorganisms.41

OTHER MEASURES

Leukocyte esterase is secreted by neutrophils at the site of infection. The calorimetric strip test for leukocyte esterase has high sensitivity and specificity for diagnosis of periprosthetic joint infection.32 It is fast, simple, and inexpensive. Synovial biopsy has higher sensitivity and specificity than aspiration alone for infected knee prostheses,35 but it has to be performed under general anaesthesia.

CONCLUSION

Joint aspiration should be performed selectively for diagnosis of periprosthetic joint infection. The specimens should be interpreted based on the results of the culture as well as the white cell count and differential. Specimen collection, transport, and analysis should be prompt to ensure yield accuracy.

DISCLOSURE

No conflicts of interest were declared by the authors.

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