MANAGING PERIPROSTHETIC JOINT INFECTION

Prophylactic peri-operative local antibiotic irrigation

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An extensive review of the spinal and arthroplasty literature was undertaken to evaluate the effectiveness of local antibiotic irrigation during surgery. The efficacy of antibiotic irrigation for the prevention of acute post-operative infection after total joint arthroplasty was evaluated retrospectively in 2293 arthroplasties (1990 patients) between January 2004 and December 2013. The mean follow-up was 73 months (20 to 139). One surgeon performed all the procedures with minimal post-operative infection.

The intra-operative protocol included an irrigation solution of normal saline with vancomycin 1000 mg/l and polymyxin 250 000 units/l at the rate of 2 l per hour. No patient required re-admission for primary infection or further antibiotic treatment. Two morbidly obese patients (two total hip arthroplasties) developed subcutaneous fat necrosis requiring debridement and one was revised because the deep capsular sutures were contaminated by the draining subcutaneous haematoma. One patient who had undergone total knee arthroplasty had unrecognised damage to the lateral superior geniculate artery and developed a haematoma that became infected secondarily four months after the surgery and underwent revision.

The use of antibiotic irrigation during arthroplasty surgery has been highly effective for the prevention of infection in the author's practice. However, it should be understood that any routine prophylactic use of antibiotics may result in resistant organisms, and the wise stewardship of the use of antibiotics is an important part of surgical practice.

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Infection continues to be one of the most costly and clinically challenging issues in total joint arthroplasty. While most of these infections are caused by gram-positive bacteria, gram-negative organisms remain a significant problem, and broad-spectrum protection is essential. Intravenous (IV) antibiotics have decreased the rates of infection effectively in major joint arthroplasty, but high rates still persist, possibly because of limited delivery of antibiotics to the joint. It is generally accepted that not only is the concentration of antibiotics in synovial fluid low, it also is transient, and affected by the use of a tourniquet. The delivery of antibiotics locally has the potential for achieving a very high concentration in the operative site, and this high level may be maintained throughout the operation, despite the use of a tourniquet.

The bactericidal effects of aminoglycoside and glycopeptide antibiotics are dependent on time and concentration, therefore their local application in high concentrations during the operation offers the greatest potential advantage over IV antibiotic delivery. The means by which the antibiotics are delivered is thus an important consideration. Pulsed lavage is reported to be significantly more effective for eradicating bacteria from the surgical site than low-pressure bulb syringe irrigation. Irrigation of the medullary canals and leaving them filled with antibiotic irrigation provides a reservoir of antibiotic which remains active for days, filling the local lymphatics and soft tissues with fluid containing bactericidal concentrations of antibiotics.

Good results have been reported following the use of irrigation with local antibiotics for many years. In 1983, Lord reported that the rates of infection decreased from 5% to 0.1% when local antibiotics were used during vascular surgery. In 1984, Benjamin and Volz reported that bactericidal levels of antibiotic were achieved in bone, tendon, muscle, and subcutaneous tissue with the irrigation of antibiotics, and the concentration remained high for > 24 hours after surgery. Since then, a substantial body of literature has been amassed in spinal and arthroplasty surgery, suggesting that locally-delivered antibiotics may achieve a dramatic decrease in the rate of acute post-operative infection.
This study sought to review the literature on local antibiotic irrigation, and to present the experience of a single surgeon who specialises in arthroplasty surgery and uses a specific intra-operative protocol for the delivery of antibiotics to the surgical site.

**Patients and Methods**

The orthopaedic and spinal surgery literature between 1980 and 30 July 2015 was reviewed electronically via the National Library of Medicine website to identify any study in which antibiotic irrigation was used locally as part of an intra-operative protocol for the prevention of infection.

**Surgical protocol.** The specific protocol used by the author involves irrigation with a solution of normal saline with vancomycin 1000 mg/l and polymyxin 250 000 units/l. It is delivered with a hand-operated plastic spray bottle (1 L; DeRoyal, Powell, Tennessee) set to deliver a stream that easily penetrates the surface of the exposed soft tissues. Irrigation begins at the time of the incision, and between the surgeon and the assistant, continues throughout the operation. At closure, the operation site is thoroughly irrigated and care is taken to pump fluid into the subcutaneous tissue. Irrigation is applied at the rate of approximately 2 l per hour in patients undergoing primary or revision arthroplasty. This rate was not meticulously calculated or measured for each patient, but used as a general approximation ensuring that copious amounts of fluid are used throughout the operation, and not just before closure of the wound.

Before insertion of the final implants, irrigation fluid is pumped into the medullary canals of the femur and tibia for the knee, or the femur for the hip.

During the operation, the surgical team wears self-ventilating, full cover hoods and gowns to prevent contamination. Post-operative drainage is used rarely, and was used in 91 (4%) patients in this study. Aspirin 325 mg twice daily was used as deep vein thrombosis prophylaxis in all low-risk patients, and warfarin in high-risk patients.

**Patient population.** Between 1 January 2004 and 31 Dec 2013, 2293 arthroplasties were undertaken by the author in 1990 patients, involving 1196 primary total knee arthroplasties (TKAs) in 991 patients, 631 primary total hip arthroplasties (THAs) in 545 patients, 285 revision TKAs in 280 patients and 181 revision THAs in 174 patients. The mean operating time was 191 minutes (standard deviation [SD] 83, 73 to 514). The mean age of the patients was 71 years (32 to 87).

All patients received cephalosporin (2 gm, IV) before surgery if not allergic to penicillin. Those who were allergic to penicillin received vancomycin (2 gm, IV). A further dose of antibiotic was given three hours later if surgery was continuing. There was no loss to follow-up at one month post-operatively. The mean follow-up was 73 months (20 to 139). A total of 31 patients (1.4%), of whom 12 died of unrelated causes, were lost to follow-up one year post-operatively.

**Results**

A total of 12 relevant articles were identified in the review of the literature. Two were prospective randomised controlled trials (RCTs) of the rate of infection; three were prospective longitudinal studies, with historical controls, two were longitudinal prospective studies of tissue and fluid concentrations of antibiotics, three were retrospective studies with historical controls, one was an animal RCT of bacterial counts, and one was a review of the literature. A total of 11 articles strongly supported the use of local antibiotics at the surgical site during arthroplasty surgery. One study reported that a significant difference was not detected between the groups with or without local intra-operative vancomycin powder. The literature review found strong evidence in favour of the use of local antibiotics in arthroplasty surgery, and questioned the wisdom of performing this type of surgery without the use of antibiotics applied locally intra-operatively.

**Clinical results.** No acute infections occurred in this group of patients. Two patients (two TKAs) with morbid obesity (body mass index [BMI] > 40) had subcutaneous fat necrosis and required debridement. One patient who underwent THA had fat necrosis and drainage, but no drainage from below the gluteus maximus and fascia lata closure. Ten deep tissue biopsies were taken for culture, and all were negative. One patient who had undergone cementless THA underwent a revision procedure because of contamination of the implants. This patient had morbid obesity and developed extensive fat necrosis and drainage from the wound two weeks post-operatively. The swab taken from the superficial drainage undertaken at the nursing home grew mixed gram-negative bacteria. At exploration, a direct connection between the wound and the capsule was found. Large absorbable sutures used for deep closure of the hip joint appeared to be contaminated. Ten tissue biopsies were taken for aerobic and anaerobic cultures, and the components were exchanged. Cultures of the tissue biopsies were negative. The wound healed and the patient has remained free of infection.

One patient (one TKA) had unrecognised damage to the lateral superior geniculate artery and developed a haematoma. He was lost to follow-up for four months and returned with perforation of the skin and spontaneous drainage that had become infected with methicillin-sensitive Staphylococcus aureus. He underwent a revision procedure with ligation of the damaged artery, and infusion with antibiotics. The infection resolved without recurrence.

One patient after surgery, no patient who had undergone THA had pain which was more than mild. Moderate pain was associated with 75 of 1481 primary or revision TKAs (5%). None had any clinical evidence of infection. All had normal levels of C-reactive protein and erythrocyte sedimentation rate. Aspiration of the joint was undertaken in these patients and all had < 100 white blood cells/ml, and round cells comprised > 80% of the cells in all cases. None complained of severe pain. No complications occurred as a result of using local antibiotic irrigation.
Discussion

High concentrations of antibiotics in the surgical wound are necessary to prevent infection when implants are inserted, and ideally these concentrations should be maintained throughout the operation from incision to wound closure. IV antibiotics achieve a relatively low concentration, with the duration above the minimal inhibitory concentration generally of < one hour.9 The bactericidal antibiotics, including the aminoglycoside and glycopeptide agents, are dependent upon time and concentration.7 The area under the concentration versus duration of concentration above the minimal inhibitory concentration curve is proportional to their bactericidal effectiveness.9

This longitudinal retrospective review of the TKAs and THAs, undertaken by a single surgeon over a ten-year period, suggests that the irrigation of local antibiotics can prevent acute infection, even with prolonged operating times in revision procedures. The wound problems requiring further surgery in three patients were related to complications of surgery, and not to acute infection. No measure can ensure that wound complications will not occur, but the low rate of acute infection in this group of primary and revision arthroplasties illustrates that long operating times, extensive exposure, and the use of revision components does not necessarily predispose patients to acute infection if antibiotic irrigation is undertaken assiduously throughout the procedure.

Although the literature on the local irrigation of antibiotics in arthroplasty surgery is not extensive, the study by Assor14 is convincing. Their prospective controlled study of TKAs included 126 patients (135 TKAs). Vancomycin paste was applied to the implants in the treatment group, and nothing was used in the controls. Both groups had the standard dose of IV prophylactic cephalosporin. The rate of early (within the first three months after surgery) infection was 0% in the treated group and 4.1% in the control group.

The most compelling evidence for the use of local antibiotics as prophylaxis against infection is reported in spinal surgery involving implants. Strom et al17 reported that the rate of infection decreased from 11% in 97 untreated patients to 0% in 156 treated patients at one-year follow-up when vancomycin powder was applied to the wound at the end of the procedure. Myung et al19 reported a study involving > 500 patients undergoing thoracolumbar fusion for scoliosis with a reduction in the rate of infection from 11% to 0.7% when vancomycin powder was used in the wound during the procedure. O’Neill et al16 reported a retrospective review of 110 posterior lumbar fusions for trauma with a rate of infection of 13% in those not protected with prophylactic vancomycin irrigation and 0% for those with antibiotic irrigation at two-year follow-up. Only one study, by Tubak et al,20 found no significant effect of using vancomycin powder in the wound after major spinal surgery. They reported a rate of infection of 1.68% with no local use of vancomycin powder, and of 1.61% when it was used in a prospectively randomised study of 907 patients over an 18-month period. They concluded that topical antibiotics do not have a protective effect in institutions with a low rate of infection. However, Sweet et al18 found that a rate of infection of 2.6% in 821 patients could be reduced with a high degree of statistical certainty to 0.2% in 911 patients (p < 0.001) by using vancomycin powder locally at a mean follow-up of 2.5 years.

The cost effectiveness of using local antibiotics during spinal fusion has been studied in detail. Godil et al15 evaluated 110 thoracolumbar fusions in a prospective controlled randomised study and found a highly significant difference in the rate of infection (13% vs 0%: p < 0.02). They found a cost savings per 100 spinal operations of $438 165 when using prophylactic local antibiotics.

Any surgeon who has used prophylactic antibiotic irrigation understands the feeling of confidence generated when a prolonged operation involves implants. Efforts to reduce the rate of infection are valuable for all parties involved. The current study supports the literature that local antibiotic irrigation is effective in reducing post-operative infection in arthroplasty surgery. However, it should be emphasised that any prophylactic use of antibiotics could lead to resistant organisms, and the wise stewardship of the use of antibiotics is an important part of surgical practice.

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L. A. Whiteside: Performed all surgical cases, designed study, analysed data, wrote the paper.

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References