One-stage exchange shoulder arthroplasty for peri-prosthetic infection

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There are few reports in the literature of the diagnosis and treatment of the infected shoulder arthroplasty. Most deal with resection arthroplasty and two-stage exchange surgery. We present our results of one-stage exchange operation as treatment for the infected shoulder arthroplasty.

Our group comprised 16 patients (ten men, six women) with 16 infected arthroplasties. By the time of follow-up, two patients had died (mean 5.8 years), two could not be located and three had already undergone revision surgery. Nine patients were thus available for clinical examination and assessment.

The infections were largely caused by staphylococci, *Propionibacterium* species and streptococci. Two were early infections (within three months of surgery) and 14 were late infections. The mean follow-up was 5.8 years (13 months to 13.25 years) when the mean Constant-Murley score was 33.6 points and the mean University College of Los Angeles score 18.3 points.

Further revision was performed in three patients. One sustained a peri-prosthetic humeral fracture, another developed an acromial pseudarthrosis after transacromial surgery and the third suffered recurrent dislocations. No patient had a recurrence of infection.

A one-stage exchange procedure using antibiotic-loaded bone cement eradicated infection in all our patients and we suggest that such a procedure is at least as successful as either a resection arthroplasty or a two-stage exchange in the management of the infected shoulder arthroplasty.

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Infection is a painful, potentially fatal condition, which occurs in up to 3.9% of patients following arthroplasty of the shoulder.[1] The risk of infection rises with the number of revisions performed.[2] As with the large joints of the lower limb, infection after arthroplasty of the shoulder can be either early (within three months of surgery) or late.[3]

There are few published studies on the diagnosis and treatment of peri-prosthetic infection in the shoulder. Despite this, a two-stage exchange procedure is the most popular treatment, followed by resection arthroplasty.[4] However, a one-stage procedure for the management of periprosthetic infection of the shoulder has been reported by Sperling et al[4] (two cases) and Coste et al[5] (three cases).

We now present our results of a one-stage exchange for peri-prosthetic infection in nine patients, a group which can serve as a pilot for later studies.

Patients and Methods

We retrospectively investigated 16 consecutive patients who had been treated by one-stage exchange arthroplasty for an infected shoulder replacement between September 1990 and October 2002. Informed consent was obtained from those patients who were reviewed and examined.

The group comprised of six women and ten men with a mean age of 68 years (45 to 90). By the time of the follow-up, two patients had died and two could not be located. A further three patients had already undergone revision surgery. This left nine patients available for examination and evaluation according to the score of Constant and Murley[6] and the University of California Los Angeles (UCLA) score.[7]

Pre-operatively, anteroposterior and axial radiographs had been taken of all the shoulders. The patients' white blood cell count, erythrocyte sedimentation rate (ESR), and level of C-reactive protein (CRP) had been determined. Joint aspiration had also been performed two weeks before surgery, the synovial fluid being examined microbiologically. Those patients who were already taking antibiotics were instructed to discontinue them for at least

Table I. Details of the 16 patients with an infected shoulder arthroplasty (9 of 16 patients were available for follow-up)

Number	Age (yrs)	Gender	Initial aetiology	Risk factors	Time to exchange surgery (mths)	Pre-operative bacteria	Intra-operative bacteria	Fistula	Mg/al CRP* (mg/dl)	ESR† (Mm/hr)	Follow-up (mths)	Constant-Murley score	Complications
1	79	M	OA‡		68	*Staphylococcus epidermidis*		No	17	35			Post-operative intestinal bleeding, could not be located for review
2	70	M	Post-traumatic OA	Diabetes mellitus	24	*Propionibacterium acnes*	*Propionibacterium acnes*	No	0.9	41	13	45	
3	69	F	Post-traumatic OA		12	*Staphylococcus capitis*	*Staphylococcus capitis*	No	1.4	21	22	48	
4	56	M	Post-traumatic OA	Diabetes mellitus	12	*Staphylococcus epidermidis*	*Staphylococcus epidermidis*	Yes	1.3	22			Died from diabetic renal failure
5	66	M	Post-traumatic OA	Prostatic carcinoma	1	*Enterococcus faecalis*	-	Yes	1.0	56	14	35	
6	56	M	Post-traumatic OA	Steroids COLD§	122	*Staphylococcus capitis*	*Staphylococcus capitis*	Yes	0.7	nd¶	14	71	
7	91	M	OA		14	-	*Propionibacterium* species	Yes	nd	nd	91	14	
8	64	F	Post-traumatic OA		3	*Propionibacterium acnes*	-	No	0.3	8	87	18	
9	88	M	OA	Steroids, asthma	24	*Streptococcus oralis*	-	No	9.2	78			Died from cardiac failure
10	58	F	Post-traumatic OA		9	*Myobacterium tuberculosis*	*Myobacterium tuberculosis*	Yes	1.2	80			Could not be located for review
11	74	F	Post-traumatic OA		5	-	*Peptococcus* species	No	2.5	56			Peri-prosthetic fracture
12	67	F	Post-traumatic OA		6	*Staphylococcus epidermidis*	*Staphylococcus aureus*	Yes	4.5	84	103	37	
13	90	F	Post-traumatic OA		5	*Staphylococcus epidermidis*, β-haemolytic *streptococcus*	*Staphylococcus epidermidis*	No	1.1	20			Acromial nonunion
14	59	F	Rheumatoid arthritis	Steroids	18	-	*Staphylococcus epidermidis*	No	4.2	34	120	19	
15	58	F	Post-traumatic OA		15	*Staphylococcus* species	*Staphylococcus* species	No	0.9	14			Recurrent dislocations
16	45	F	Osteosarcoma	Osteosarcoma	6	*Propionibacterium acnes*	*Propionibacterium acnes*	Yes	0.2	21	159	19	

* CRP, C-reactive protein
† ESR, erythrocyte sedimentation rate
‡ OA, osteoarthritis
§ COLD, chronic obstructive lung disease
¶ not documented

one week before aspiration. This was performed in a special room and under aseptic conditions in accordance with the Guidelines for Hospital Hygiene and Prevention of Infectious Diseases issued by the Robert Koch Institute in Berlin.[8] We performed the aspiration through an anterior approach, without local anaesthesia. The samples of synovial fluid were transported to the laboratory in sterile tubes, without additional substrates, and in airtight anaerobic containers with a chemically-created moist, oxygen-free atmosphere.

All the samples were Gram-stained and injected into Brain Heart Infusion broth (BHI; bioMérieux, Marcy l'Étoile, France), thioglycollate-meat-liver serum medium[9] and special media according to Lodenkämper and Stinen.[10] They were smeared onto Columbia blood (aerobic, 5% CO_2; bioMérieux) and *Brucella* agar (anaerobic; bioMérieux) plates and incubated. The cultures were observed for 14 days. Sensitivity testing was carried out according to the DIN Standard 58940.[11]

Before antibiotics were given, intra-operative biopsies were taken from the capsule and prosthesis-bone interface which were also sent for bacteriological analysis. In all patients the infected joint replacement was exchanged for a cemented prosthesis as a one-stage procedure. The infected tissue was radically excised and the operation site irrigated by pulsatile lavage using polyhexanide (Lavasept, Fresenius-Kabi AG, Bad Homburg, Germany). Fifteen patients received a hemiprosthesis (ENDO-Modell Waldemar Link Co, Hamburg, Germany) and one an inverse total shoulder replacement (DePuy, Sulzbach, Germany). In this latter case the normally uncemented components were secured with polymethylmethacrylate (PMMA) bone cement. Antibiotics, based upon each patient's bacterial sensitivity pattern, were added to the cement in all patients. When pre-operative cultures had been negative (three patients), the choice of antibiotic was based upon our experience (calculated antibiotic therapy).

After surgery, the operated shoulder was immobilised in an abduction cushion and physiotherapy began on the second post-operative day. Peri-operative systemic antibiotics were first administered intravenously and, in some cases,

later taken orally. The duration of treatment depended upon both the clinical findings and the fall in the level of inflammatory markers such as the level of CRP.

Results

The mean time to exchange surgery was 21.5 months (1 to 122). Fourteen patients had an infected hemiprosthesis and two a total prosthesis.

There were two early and 14 late infections. Before we performed a one-stage septic exchange procedure, four patients had already undergone one revision operation and one patient had two revisions.

Seven patients had an increased risk of infection; two had diabetes mellitus, two had malignant tumours and three were taking steroids.

In 13 patients (81.3%), bacteria had been identified pre-operatively. In the other patients the bacteria were isolated from the intra-operative biopsies. One patient had a mixed infection of *Staphylococcus epidermidis* and beta-haemolytic streptococci. In the remaining patients only one pathogen was identified (Table I).

In one patient, the complete laboratory data had not been documented and in another the ESR had not been documented. The white blood cell count (mean 6.5/nl; 3.7 to 12.8) was unremarkable except in one patient. The level of CRP was elevated in all but one patient (reference range < 0.3 mg/dl; mean 3.08 mg/dl; 0.20 to 17.0). The ESR was elevated in 13 of 15 patients with no data being available for one (reference range < 15 mm/hr; mean 41 mm/hr; 8 to 80).

Systemic antibiotic therapy was begun intra-operatively and continued for a mean of 8.6 days (5 to 14). The patient infected with *Mycobacterium tuberculosis* was treated with antituberculous drugs for 180 days and was not included in our calculation of the length of treatment. Systemic antibiotics were stopped if the CRP began to decline, and if the post-operative course was uneventful and the wound was unremarkable. One patient suffered gastrointestinal bleeding peri-operatively.

The mean follow-up period was 5.8 years (13 months to 13.25 years). The mean Constant-Murley score was 33.6 of 100 points. The mean value for pain was 7.7 of 15, for function/daily activities 5.1 of 20, for range of movement 4.9 of 40 and for strength 10.6 of 25.

Using the UCLA score our patients achieved a mean of 18.3 of a maximum of 35 points. The mean value for pain was 5.8 of 10, for function 4.7 of 10, for range of movement 1.3 of 10 and for strength 2.2 of 5. Six patients were satisfied with the result and considered themselves to be better than before the revision operation. Three were not satisfied and considered themselved to be worse. These three patients had cranial subluxation of the prosthesis although none were loose.

After the one-stage exchange procedure, revision was necessary in three patients. One sustained a peri-prosthetic humeral fracture and was treated by implantation of a long-stemmed prosthesis. Another developed an acromial pseudarthrosis after transacromial surgery requiring revision. The third patient suffered recurrent dislocation which was treated by a soft-tissue revision.

None of the nine patients (including those who died) had recurrence of infection during the follow-up period.

Discussion

The clincial picture of a peri-prosthetic infection is non-specific. The most predominant symptom is pain. Typical signs of infection such as fever, fistulae, erythema, general malaise, or even septicaemia are rare. Laboratory tests such as the CRP value, ESR and white blood cell count in the synovial fluid are important indicators of infection.[5,12,13] Microbiological examination of aspirated fluid is essential both for the identification of pathogens and the determination of antibiotic sensitivities.

In our study both the mean CRP and ESR values were raised although the white blood cell count in the blood was normal in all but one patient. These results correlate with those already in the literature[4,5,13] and highlight the value of estimation of the CRP.

Pre-operative aspiration allowed us to identify the infecting organisms in 13 of the 16 patients (81.3%). In the remaining patients the pathogens were identified by intra-operative biopsy. The percentage of *Propionibacterium* species was unexpectedly high, being the most frequently identified pathogen after coagulase-negative staphylococci. The third most common organism was streptococcus. Sperling et al[4] investigated 32 infected shoulder replacements, 18 of which had undergone a pre-operative aspiration. Organisms were detected in 14, although the species were not named. The pathogens detected intra-operatively were *Staphylococcus aureus* (13 cases), coagulase-negative staphylococci (nine), *Propionibacterium* species (five), *Pseudomonas* species (four) and various other bacteria in the remainder. However, some cases had infections caused by multiple organisms. In the patients reported by Codd et al,[2] joint aspiration was performed on seven of 18 patients. The pathogen was identified in only two. Jerosch and Schneppenheim[12] reported 12 patients with infected shoulder prostheses but were only able to identify the pathogen in four. In three patients the infecting organism was *Staph. aureus* and in the fourth it was *Staph. epidermidis*. Their study gives no information about when the samples were taken (before or during operation) or about the methods of microbiological examination used.

Uninterrupted antibiotic therapy and inappropriate transport of samples considerably reduce the rate of bacterial identification. The type of sample (aspiration, biopsy, smear) also plays a role. In our experience swabs are unsuitable for the identification of organisms in cases of peri-prosthetic infection. The laboratory techniques used also have a considerable influence. Because samples often contain only a small number of bacteria, optimal media must be used, which must be incubated for a sufficiently

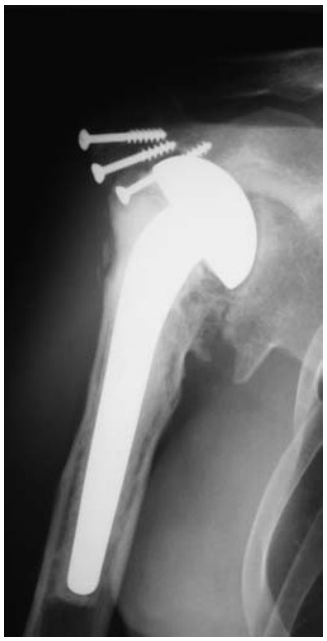

Fig. 1a

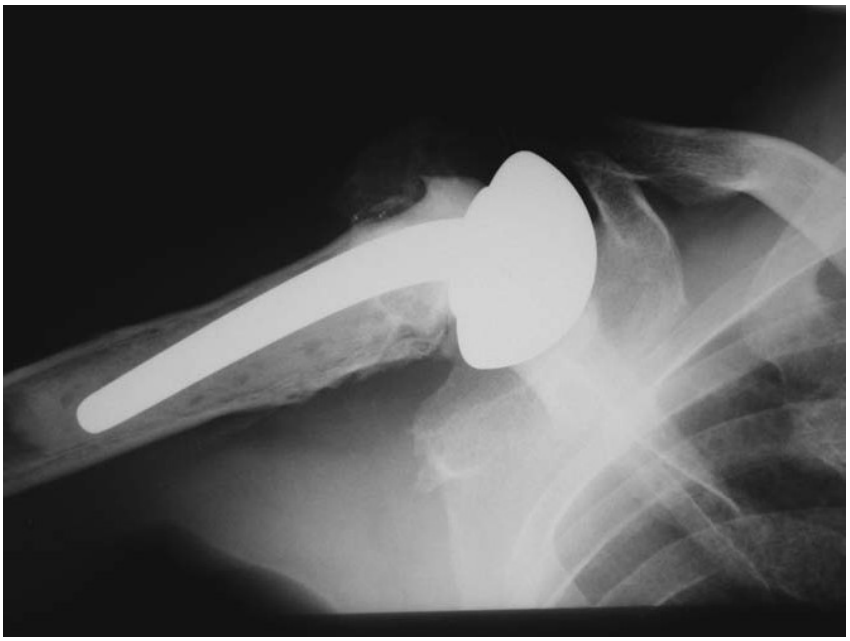

Fig. 1b

Radiographs of a right shoulder arthroplasty, a) which became infected 12 years after insertion, possibly a result of steroid administration and b) one year after a one-stage exchange procedure (in abduction).

long period under both aerobic and anaerobic conditions. A four-day incubation period is, in most cases, insufficient.[14]

For our patients, we examined the synovial fluid from pre-operative aspiration as well as capsular tissue and bone removed intra-operatively and before starting antibiotic treatment. The samples were observed under aerobic and anaerobic conditions for 14 days.

We routinely determine the inflammatory markers, and perform joint aspiration before admission to our clinic, for all patients experiencing diffuse pain in the shoulder after arthroplasty, even if there is another recognisable cause such as subacromial impingement, instability, acromioclavicular arthritis or damage to the rotator cuff. Intra-operatively, at least three samples must be taken before prophylactic antibiotic treatment is begun in order not to jeopardise the culture of bacteria. Samples from the capsule and cement-bone interface increase the rate of identification of the pathogen.[14]

Imaging techniques such as conventional radiography, CT and MRI do not provide sufficient information about infection. The role of bone scintigraphy for the shoulder has not been widely investigated, although it is known that its specificity and sensitivity for the large joints of the lower limb are low.[14] Ultrasonography can show clearly the extent of joint fluid, but is inadequate for the diagnosis of peri-prosthetic infection (Fig. 1).

The options for treatment are either a debridement while leaving the implant *in situ*, a one- or two-stage exchange arthroplasty, or a resection arthroplasty. Our review of the literature yielded little information about therapeutic recommendations and success rates.

Infection of a shoulder arthroplasty is often associated with risk factors such as rheumatoid arthritis, diabetes mellitus, immunosuppressive medication and tumours.[13] Risk factors were present in seven of the 16 patients in our study.

Coste et al[5] undertook a multicentre study of 49 infected shoulder arthroplasties. A resection arthroplasty was performed in ten but, even so, the infection persisted in 30%. One-stage exchange surgery was undertaken in three cases, with eradication of infection in all. Two-stage exchange surgery was performed in ten, with failure in 40%. The authors therefore recommended debridement and exchange of the arthroplasty, with concurrent adequate administration of antibiotics.

Sperling et al[4] reported 32 infected shoulder arthroplasties of which 21 were treated by resection arthroplasty (group 1), six by debridement with the prosthesis *in situ* (group 2), two by a one-stage exchange (group 3) and three by a two-stage exchange (group 4). Infection persisted in 29% of the patients in group 1 and in 50% of those in both groups 2 and 3. There was no persistence of infection in group 4. The authors were also able to show that patients with a resection arthroplasty had more pain and less movement than those with an implant *in situ*. They recommended a two-stage exchange procedure although only three of their patients had been treated in this way.

We prefer a one-stage procedure because it offers considerable advantages over other methods. It is less expensive since the patient only undergoes one operation and stays in

hospital for a shorter period. This contributes significantly to a patient's comfort. The functional result is also better than that achieved by resection arthroplasty. Our preliminary results indicate that a one-stage exchange is at least as successful as either a resection arthroplasty or a two-stage exchange for the eradication of infection in a shoulder arthroplasty. However, a larger, controlled, randomised study would be needed to confirm this.

Our study has two disadvantages. First, the number of patients is small in comparison with studies on the infected hip and knee replacements. Secondly, we performed one-stage exchange procedures only and had no comparative group. Nevertheless, we believe that our work gives valuable information about the treatment of infected shoulder arthroplasties since we were able to eradicate the infection by a one-stage exchange in all our patients. There is no similar study in the literature to date.

At follow-up, seven of our patients reported slight pain and two had severe pain. These were the two patients with cranial subluxation of a hemiprosthesis.

The range of movement of our patients, with a mean abduction of 51.6° (40° to 110°) was less satisfactory. This may be because of the intra-operative debridement of all infected tissue, including the rotator cuff. As a consequence, active movement of the shoulder was restricted and the central position of the prosthetic head in the glenoid was no longer secure. This made it difficult to achieve a good functional result when a conventional hemiprosthesis was used.

At follow-up, two of our patients reported that they could perform light activities, two could perform light activities within a domestic environment only and five were able to undertake household activities, shop, drive a car, wash their hair and dress and undress. Restricted movement of the shoulder, therefore, does not appear to be a hindrance in the activities of daily living.

Six of the nine patients who we followed up were generally satisfied with their situation, although the three with cranial subluxation were not satisfied. Despite this, they did not want further surgical intervention.

The patient with an inverse prosthesis had only slight pain at follow-up with active abduction of 110°. Further studies will be performed to investigate the value of this system for the one-stage exchange of an infected shoulder arthroplasty. However, the overall results of our study indicate that the eradication of infection is possible with a one-stage exchange procedure thereby avoiding the disadvantages of either a resection arthroplasty or two-stage exchange surgery.

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