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ORIGINAL PAPER

Stage-dependant management of septic arthritis of the shoulder in adults

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Abstract Diagnostic and therapeutic standards relating to septic conditions of the shoulder are rarely documented in the literature. For this study, patients suffering from septic shoulder arthritis were prospectively enrolled. Staging was based on the criteria of Gächter (Stutz et al., Knee Surg Sports Traumatol Arthrosc 8:270–274, 2000), and assessment of functional outcome was based on a self-assessed Constant score (Boehm et al., Unfallchirurg 107:397–402, 2004). Patients were separated into three groups according to the CEBI-classification reported by Pfeiffenberger and Meiss (Arch Orthop Trauma Surg 115:325–331, 1996). Forty-three patients were enrolled. Group I contained 21% of patients, while 23% were assigned to group II, and 56% to group III. *Staphylococcus aureus* was found in 71%. Eight patients were treated arthroscopically, and 35 received open surgery. None of the implants could be preserved. The mean self-assessed Constant score after 26±7 months was 74±9 points in group I, 63±14 points in group II, and 53±14 points in group III. Diagnostic work-up consisted of laboratory analysis including CRP and joint aspiration. Arthroscopic procedures can be effective when implemented early. With regard to implants and chronic symptoms, primary removal should be critically reconsidered.

Résumé Les arthrites septiques de l'épaule sont rarement documentées dans la littérature. Patients et méthode : un certain nombre d'arthrites septiques ont été évaluées avec l'utilisation d'un critère de classement (Gächter) et de critères fonctionnels avec le score de Constant. Les patients ont été séparés en trois groupes selon la classification CEBI. Résultats : 43 patients dont 21% affectés au groupe I, 23% dans le groupe II et 56% dans le groupe III. Un staphylocoque doré a été retrouvé dans 71% des cas. 8 patients ont été traités par arthroscopie et 35 par chirurgie sanglante. Aucun implant n'a pu être conservé. La moyenne du score de Constant après 26±7 mois de suivi a été de 74±9 points dans le groupe I, de 63±14 points dans le groupe II et de 53±14 points dans le groupe III. En conclusion : le diagnostic nécessite des examens de laboratoire incluant la CRP et des prélèvements au niveau de l'épaule par aspiration. Le traitement par arthroscopie est un traitement qui peut avoir des effets positifs s'il est réalisé précocement. En ce qui concerne les implants, après une longue période d'évolution, ceux-ci doivent être enlevés. Néanmoins, cette ablation nécessite une analyse critique.

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Introduction

Articular infections still represent serious situations which can potentially lead to irreparable joint damage [12, 16]. As bacterial septic arthritis of the glenohumeral joint is of low prevalence [4, 5], relatively few reports regarding diagnosis/therapy have been published [11]. Apart from a delay in instituting treatment, other determinants for poor outcome include virulence of the infecting organism and underlying comorbidities [11]. Surgical treatment options include needle aspiration [10], arthroscopic irrigation [6], open arthrotomy with debridement [8], and removal of prosthetic components with or without temporary prosthetic spacer beads [8]. The purpose of this study was to present experience in the treatment of septic conditions of the shoulder joint encountered at our institution between 2001 and 2006.

Patients and methods

From January 2001 to December 2006, all patients suffering from septic glenohumeral arthritis were enrolled in this study. A complete history and physical examination, as well as the interval from onset of symptoms to time of diagnosis, were recorded. Patients were separated into three groups according to the classification of exogenic bacterial infections (CEBI) [11]. Laboratory studies included white blood cell (WBC) count as well as C-reactive protein level (CRP). Standard radiographs were performed for all patients. Ultrasound (US) was also performed if indicated. Patients underwent intra-articular aspiration if joint effusion was seen. Contrast enhanced computerised axial tomography (CT) scan or magnetic resonance imaging (MRI) was only added in cases of unspecific clinical and/or ultrasound findings, of suspected chronic or late infection, or in cases of suspected septic spread. All joints were consecutively surgically revised. The duration of symptoms as well as the clinical extent of infection basically determined the surgical strategy. Arthroscopic debridement was performed using standard portals. For irrigation, 5–20 litres of normal saline solution was used. A closed suction drain was inserted. Open debridement and jet lavage included arthrotomy, radical debridement, jet lavage with 5–20 litres of normal saline solution, and insertion of drains. An additional vacuum assisted closure (VAC) was applied when a two-stage revision was undertaken. In patients with osteosynthetic or prosthetic implants a primary implant removal, debridement, jet lavage, and application of VAC were performed if evidence of periprosthetic infection was present. Septic arthritis of the shoulder joint was confirmed by positive cultures of the joint fluid and/or by histological signs for suppurative synovitis. Staging was based on the criteria of Gächter [13]. All patients were initially treated with intravenous antibiotics. Functional results were evaluated by the self-assessed Constant score [2].

For comparison of different groups ANOVA on ranks followed by the Student-Neumann-Keuls test was used, and for correlation Pearson's correlation coefficient was calculated ($p<0.05$).

Results

Forty-three patients were enrolled (27 men, 16 women; mean age 66±12 years). Twenty-two right and 21 left shoulders were affected. In 38 (88%) patients at least one risk factor was found (see Fig. 1, Table 1). Twenty-six (61%) patients presented with isolated septic arthritis, 13 (30%) with arthritis and osteomyelitis of the proximal

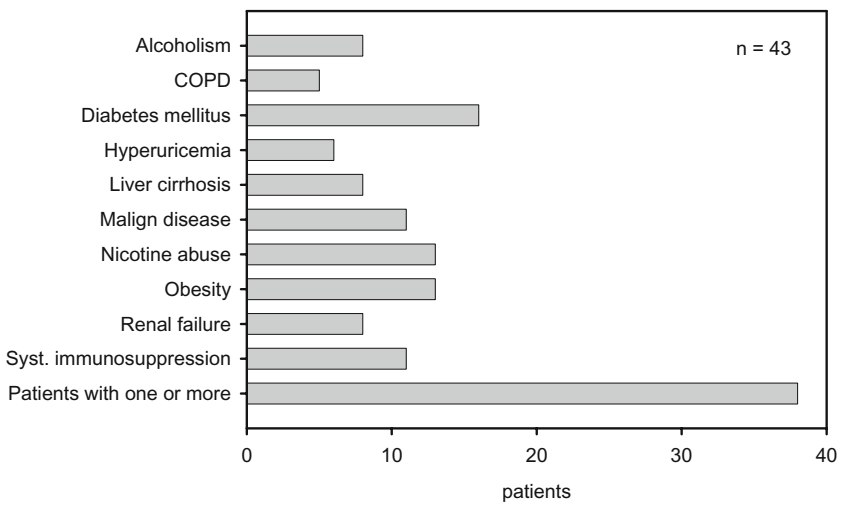

Fig. 1 Comorbidities

Table 1 Patient profiles

Patient	Gender	Age	CEBI	Risk factors	Aetiology	Site	Onset of symptoms until diagnosis (days)	CRP	WBC	US	CT	MRI	Joint aspirate
1	M	63	I	–	Mini-open repair	Peri	2	10.3	9	y/+	n	n	–
2	M	58	I	–	Mini-open repair	Arthr	3	18	11.4	y/+	n	n	y/+
3	M	58	I	Diabetes, obesity	Steroid injections	Arthr	3	28	20.3	y/+	n	n	y/+
4	M	58	I	Diabetes, obesity, nicot., COPD	Steroid injections	Arthr	3	32	21.6	y/+	n	n	y/+
5	M	82	I	Myeloma, chemoth., renal insufficiency	Haematogenous (pneumonia, neutropenia)	Arthr	3	23.1	0.7	y/+	y/+	n	y/+
6	M	62	I	Myeloma, chemotherapy	Steroid injections	Arthr	4	12.4	5.2	y/-	n	y/+	y/+
7	F	74	I	Diabetes	Steroid injections	Arthr	4	41	17.9	y/+	n	n	y/+
8	F	74	I	Nicot.	Steroid injections	Arthr	5	39.9	17.7	y/+	n	n	y/+
9	F	98	I	Diabetes, nicot., COPD, systemic cortisone	Haematogenous (diabetic foot ulcer)	Arthr	5	37.4	23	y/+	n	n	–
10	M	61	II	Obesity, alcoholism, liver cirrhosis	Haematogenous (gluteal abscess)	Arthr	6	42.1	21	n	n	y/+	y/+
11	M	69	II	–	Steroid injections	Arthr	7	5.4	8.9	y/+	n	n	y/+
12	F	73	II	Breast ca., diabetes	Unknown	Peri	7	27.5	10.5	y/+	n	n	–
13	M	69	II	Diabetes	Steroid injections	Arthr	7	37.7	11.3	y/+	n	n	y/+
14	M	76	II	Prostatic ca., chemotherapy, diabetes	Proximal humeral fracture (nail)	Arthr+ost	7	16.6	10.9	y/+	y/+	n	y/+
15	M	73	II	Prostatic ca., nicot.	Hemiarthroplasty	Arthr+ost	7	9	9.6	y/+	y/+	n	y/+
16	M	52	II	Alcoholism, liver cirrhosis	Glenoid component change	Arthr+ost	7	4.7	9.7	y/+	y/+	n	y/+
17	F	49	II	Diabetes, obesity	Haematogenous (diabetic foot ulcer)	Arthr	8	27.5	25.9	y/+	n	n	–
18	M	72	II	Diabetes, obesity, nicot., alcohol, liver cirrhosis, renal insufficiency	Haematogenous (diabetic foot ulcer)	Arthr	8	17.2	25.1	y/+	n	n	–
19	M	74	II	Diabetes, obesity, nicot., COPD, syst. cortisone, renal insufficiency	Haematogenous (diabetic foot ulcer)	Arthr	9	33.8	15.7	n	y/+	n	y/+
20	M	37	III	Myeloma	Revision arthroplasty	Arthr+ost	14	4.1	15.6	n	y/+	n	y/+
21	M	60	III	Obesity	Haematogenous (gluteal abscess)	Arthr	14	31.1	11	y/-	n	y/+	y/+
22	M	59	III	Obesity	Haematogenous (perianal abscess)	Arthr	14	17.2	10.1	y/+	n	n	–
23	M	59	III	Diabetes, obesity, nicot., alcoholism, liver cirrhosis	Hemiarthroplasty	Arthr+ost	14	9.1	6.8	n	y/+	n	–
24	F	83	III	Obesity, nicot., COPD, syst. cortisone	Proximal humeral fracture (nail)	Arthr+ost	14	4.4	14.4	y/+	y/+	n	–
25	M	77	III	Myeloma, nicot., alcoholism, liver cirrhosis, COPD, chemotherapy	Haematogenous (chronic tibial osteomyelitis)	Peri	14	9.8	6.8	y/+	n	y/+	–
26	M	49	III	Nicot., alcoholism, liver cirrhosis, renal insufficiency	Unknown	Arthr	14	43.7	16.3	y/+	n	n	–
27	M	74	III	Diabetes, obesity, renal insufficiency, syst. cortisone	Haematogenous (pneumonia)	Arthr	20	29.2	9.1	y/+	y/+	n	–
28	F	67	III	–	Total shoulder arthroplasty	Arthr+ost	21	6.6	8.3	n	y/+	n	y/+
29	M	60	III	Syst. cortisone	Mini-open repair	Arthr	21	19.9	8	y/+	n	n	–

Table 1 (continued)

Patient	Gender	Age	CEBI	Risk factors	Aetiology	Site	Onset of symptoms until diagnosis (days)	CRP	WBC	US	CT	MRI	Joint aspirate
30	F	80	III	Diabetes	Steroid injections	Arthr	21	16.2	11.8	y/+	n	y/+	y/+
31	F	49	III	Nicot.	Steroid injections	Arthr	21	27.5	17	y/+	n	n	–
32	F	64	III	Renal insufficiency	Haematogenous (pneumonia)	Arthr	21	21.2	17	y/+	y/+	n	–
33	F	72	III	Renal ca., renal insufficiency	Haematogenous (perianal abscess)	Arthr	21	40.2	11.3	y/+	y/+	n	y/+
34	M	66	III	Nicot., alcoholism, liver cirrhosis	Humeral head fracture (locking plate)	Arthr+ost	28	5.2	16.3	n	y/+	n	y/+
35	F	52	III	Breast ca.	Total shoulder arthroplasty	Arthr+ost	35	17.5	6	n	y/+	n	–
36	F	56	III	–	Steroid injections	Peri	42	22.4	10.9	y/+	n	n	–
37	M	73	III	Obesity	Arthroscopy	Arthr	56	7.1	7.7	y/-	n	y/+	y/+
38	M	71	III	Obesity	Mini-open repair	Arthr	84	5.8	6.2	y/+	n	n	–
39	F	66	III	Syst. cortisone	Total shoulder arthroplasty	Arthr+ost	84	22.4	14.3	n	y/+	n	–
40	M	49	III	Diabetes, nicot., alcoholism, liver cirrhosis	Steroid injections	Arthr	84	21.8	14	y/+	n	n	–
41	F	76	III	Diabetes	Proximal humeral fracture (nail)	Arthr+ost	140	9	8.5	n	y/+	n	–
42	F	60	III	Uterine ca.	Revision arthroplasty	Arthr+ost	280	4.5	8	n	y/+	n	–
43	M	77	III	Prostatic ca., diabetes, renal insufficiency	Humeral head fracture (locking plate)	Arthr+ost	290	24.3	9.5	n	y/+	n	y/+

CEBI classification of exogenic bacterial infections, *CRP* C-reactive protein level, *WBC* white blood cell, *US* ultrasound, *CT* computerised axial tomography, *MRI* magnetic resonance imaging, *nicot.* nicotine abuse, *COPD* chronic obstructive pulmonary disease, *ca.* cancer, *arthr* arthritis, *ost* osteomyelitis, *peri* periarticular, *syst.* systemic

humerus, and four (9%) with periarticular soft-tissue infection. Eleven (26%) reported intraarticular corticosteroid injections, seven (16%) joint replacement, five (12%) osteosynthesis, four (9%) mini-open repair, and one (2%) arthroscopy. Septic spread with confirmed primary focus was found in 12 (28%) patients, and in two (5%) aetiology remained unknown (see Table 2). According to CEBI, nine (21%) patients were assigned to group I with a time period of onset of symptoms until diagnosis/therapy of 4±1 days, ten (23%) patients were placed in group II with 7±1 days, and 24 (56%) patients to group III with 57±77 days. Forty-two patients (98%) had primarily been treated in other departments and were assigned to our institution due to deteriorating medical conditions. In one patient infection occurred as a result of hemiarthroplasty at our institution, corresponding to an infection rate of 0.03% during the study period.

Initial findings

All patients in group I suffered from pain/discomfort or limitation of range motion in the shoulder. Seven (78%) presented with local warming, one with swelling, and one with redness. Mean body temperature was measured at 39±2°C. In group II body temperature was 37±1°C and in group III 36±2°C. The WBC was measure to be $16\pm6\times10^9$/l in group I, $15\pm7\times10^9$/l in group II, and $11\pm4\times10^9$/l in group III. Mean CRP in group I was 27±12 mg/dl, in group II 22±14 mg/dl, and 18±11 mg/dl in group III (see Table 1). All joint aspirates revealed a white cell count >30,000 cells/ml.

Imaging

Radiographs in groups I and II were interpreted as normal. In group III, moderate to severe degenerative changes were seen in 14 patients (33%). In four patients a symptom duration of >84 days and osteosynthesis/prosthesis loosening was seen. Ultrasound (US) was assessed as positive if significant joint effusion was present. US was performed in 32 (74%) resulting in three false negative findings (sensitivity 0.91). One patient with neutropenia additionally received a whole body contrast enhanced CT to exclude further foci. Out of group II, three patients received an

Table 2 Patient treatments

Patient	Gender	Age	CEBI	Surgical treatment	Gächter stage	Revisions	Causative organism	Antibiotic treatment (iv)	ICU	Hospitalisation (days)	Two-stage arthroplasty	Constant score
1	M	63	I	Open debridement and jet lavage	–	1	Sterile	Amoxicillin/ clavulanate	n	7	n	78
2	M	58	I	Open debridement and jet lavage	I	1	Sterile	Cefuroxime	n	7	n	82
3	M	58	I	Arthroscopic lavage and debridement	I	1	*S. aureus*	Cefuroxime	y	15	n	84
4	M	58	I	Arthroscopic lavage and debridement	I	1	*S. aureus*	Amoxicillin/ clavulanate	y	12	n	78
5	M	82	I	Open debridement and jet lavage	I	2	*S. aureus*	Piperacillin/ tazobactam + clindamycin	y	18	n	68
6	M	62	I	Arthroscopic lavage and debridement	I	1	*S. aureus*	Cefuroxime	n	7	n	78
7	F	74	I	Arthroscopic lavage and debridement	I	1	*S. aureus*	Cefuroxime	n	10	n	68
8	F	74	I	Arthroscopic lavage and debridement	I	1	*S. aureus*	Amoxicillin/ clavulanate	n	10	n	72
9	F	98	I	Arthroscopic lavage and debridement	I	2	*S. aureus*	Cefuroxime	y	7	n	56
10	M	61	II	Arthroscopy > open debridement, jet lavage and VAC	III	4	*S. aureus*	Piperacillin/ tazobactam + ciprofloxacin	y	31	Total	68
11	M	69	II	Arthroscopic lavage and debridement	II	3	*S. aureus*	Cefuroxime	n	30	n	72
12	F	73	II	Open debridement and jet lavage	–	1	*S. aureus*	Cefuroxime	y	8	n	82
13	M	69	II	Arthroscopy > open debridement, jet lavage and VAC	III	4	*S. aureus*	Amoxicillin/ clavulanate	n	14	n	72
14	M	76	II	Primary Implant removal, debridement, jet lavage and VAC	II	3	*S. aureus*	Piperacillin/ tazobactam + clindamycin	y	49	Resection	62
15	M	73	II	Secondary Implant removal, debridement, jet lavage and VAC	III	4	*S. aureus*	Cefuroxime	n	70	Inverted	48
16	M	52	II	Secondary implant removal, debridement, jet lavage and VAC	II	5	*S. epider.*	Cefuroxime + cotrimoxazole	n	64	Total	62
17	F	49	II	Open debridement, jet lavage and VAC	II	4	*S. agal.*	Piperacillin/ tazobactam + ciprofloxacin	y	56	n	68
18	M	72	II	Open debridement, jet lavage and VAC	II	5	*S. aureus*	Cefuroxime	y	84	n	66
19	M	74	II	Open debridement, jet lavage and VAC	II	9	*S. aureus*	Cefuroxime > meropenem + clindamycin	y	42	n	62

Table 2 (continued)

Patient	Gender	Age	CEBI	Surgical treatment	Gächter stage	Revisions	Causative organism	Antibiotic treatment (iv)	ICU	Hospitalisation (days)	Two-stage arthroplasty	Constant score
20	M	37	III	Primary implant removal, debridement, jet lavage and VAC	III	5	*S. epider.*	Cefuroxime + ciprofloxacin	n	32	Inverted	72
21	M	60	III	Arthroscopic lavage and debridement	II	3	*S. aureus*	Cefuroxime	n	21	n	74
22	M	59	III	Secondary implant removal, debridement, jet lavage and VAC	III	10	Sterile	Cefuroxime	n	56	Total	64
23	M	59	III	Secondary implant removal, debridement, jet lavage and VAC	IV	9	*S. aureus*	Cefuroxime	n	49	Resection	40
24	F	83	III	Primary implant removal, debridement, jet lavage and VAC	IV	5	MRSA	Vancomycin + rifampicin	n	39	n	54
25	M	77	III	Open debridement and jet lavage	–	3	*S. aureus*	Cefuroxime	y	21	n	78
26	M	49	III	Open debridement, jet lavage and VAC	III	5	*S. aureus*	Vancomycin + rifampicin	y	42	n	60
27	M	74	III	Open debridement, jet lavage and VAC	IV	6	*S. pneu.*	Penicillin > meropenem	y	56	n	58
28	F	67	III	Primary implant removal, debridement, jet lavage and VAC	IV	6	*S. epider.*	Ciprofloxacin + cefuroxime	n	84	Inverted	52
29	M	60	III	Open debridement and jet lavage	IV	2	Sterile	Amoxicillin/ clavulanate	n	14	n	50
30	F	80	III	Open debridement and jet lavage	IV	3	*S. aureus*	Cefuroxime	n	28	n	48
31	F	49	III	Open debridement and jet lavage	IV	4	*S. aureus*	Cefuroxime + clindamycin	n	42	Total	66
32	F	64	III	Open debridement, jet lavage and VAC	IV	3	*S. aureus*	Cefuroxime	n	17	n	62
33	F	72	III	Open debridement, jet lavage and VAC	IV	3	Sterile	Amoxicillin/ clavulanate	n	16	n	62
34	M	66	III	Primary implant removal, debridement, jet lavage and VAC	IV	4	*E. faecalis*	Ciprofloxacin	n	18	Resection	48
35	F	52	III	Primary implant removal, debridement, jet lavage and VAC	IV	6	*S. epider.*	Cefuroxime > linezolid	n	85	Total	42
36	F	56	III	Open debridement and jet lavage	–	3	*S. aureus*	Cefuroxime	n	14	n	68
37	M	73	III	Open debridement and jet lavage	IV	4	*S. aureus*	Cefuroxime	n	21	n	54
38	M	71	III	Open debridement and jet lavage	IV	7	*S. aureus*	Cefuroxime	n	98	n	52
39	F	66	III	Primary implant removal, debridement, jet lavage and VAC	IV	3	*S. aureus*	Cefuroxime	y	21	Total	44

Table 2 (continued)

Patient	Gender	Age	CEBI	Surgical treatment	Gächter stage	Revisions	Causative organism	Antibiotic treatment (iv)	ICU	Hospitalisation (days)	Two-stage arthroplasty	Constant score
40	M	49	III	Open debridement and jet lavage	IV	4	*E. coli*	Moxifloxacin > meropenem	n	16	n	30
41	F	76	III	Primary implant removal, debridement, jet lavage and VAC	IV	5	MRSA	Vancomycin + rifampicin > linezolid	n	35	Resection	27
42	F	60	III	Primary implant removal, debridement, jet lavage and VAC	IV	4	*S. agal.*	Cefuroxime	n	35	Inverted	32
43	M	77	III	Primary implant removal, debridement, jet lavage and VAC	IV	4	*S. aureus*	Cefuroxime	n	28	Resection	32

CEBI classification of exogenic bacterial infections, *ICU* intensive care unit, S. aureus *Staphylococcus aureus*, S. epider. *Staphylococcus epidermis*, *MRSA* Methicillin resistant *S. aureus*, S. agal.*Streptococcus agalactiae*, S. pneu. *Streptococcus pneumoniae*, E. coli *Escherichia coli*

additional contrast enhanced CT to evaluate periprosthetic loosening. One received MRI only because additional spondylodiscitis was suspected. In group III, additional MRI was performed in two patients; in both of these cases MRI was very conclusive so the decision against arthroscopy was made (see Table 1).

Microbiology

Causative organisms were identified in 38 (88%) cases. All patients with negative cultures had previously received oral antibiotics. Synovial histology was consistent with septic arthritis in all cases. *Staphylococcus aureus* was found in 27 (63%), *Staphylococcus epidermidis* in four (9%), *Staphylococcus agalactiae* in two (5%), and Methicillin resistant *S. aureus* (MRSA) in two cases (5%). *Escherichia coli, Escherichia faecalis,* and *Staphylococcus pneumoniae* were each found in one (see Fig. 2). All patients with exogenic infection, suffering from organisms others than *S. aureus* had received the potential inoculation in a hospital setting (see Table 2). Analysing the antibiotic sensitivities in group I, all could have been treated with cefuroxime. The mean duration of IV therapy was 9±3 days, and subsequent oral therapy was 34±7 days. In group II six (60%) patients had initially received cefuroxime. In seven (70%) patients cefuroxime would have been sufficient for the shoulder joint infection according to the antibiotic sensitivities. Mean IV therapy in group II lasted for 24±9 days, with subsequent oral equivalent therapy for a further 30±5 days. Of group III, 15 (63%) patients were initially treated with cefuroxime, two of these received additional ciprofloxacin, and one additional clindamycin for urinary tract infection. In one patient cefuroxime treatment had to be converted to linezolid in accordance with the sensitivities. Two patients (8%) received amoxicilline/clavulanate and three (13%) vancomycin/rifampicin. In one of these patients therapy was converted to linezolid. One patient received penicillin, one moxifloxacin, and in both cases therapy was changed to meropenem. In 18 (75%) cefuroxime would have been sufficient. Mean IV therapy in group III lasted for 25± 10 days, with subsequent oral equivalent therapy for a further 52±17 days.

Therapy

Hospital stay was significantly shorter in group I (10± 4 days) than in group II (45±25 days) and group III (37± 24 days; $p<0.05$). A strong correlation between the initial

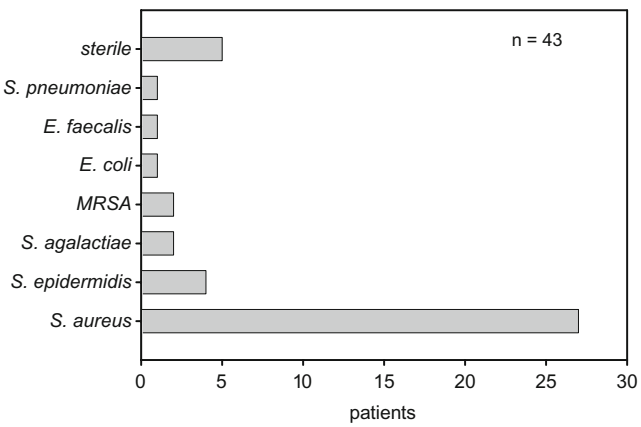

Fig. 2 Causative organisms

duration of symptoms and the duration of hospital stay was found (r=0.76, p<0.05; see Fig. 3). With regard to Gächter stage, all patients of group I were at stage I. In group II the mean stage was 2.3±0.5, whereas none of the patients were at stage I. In group III the mean stage was 3.8±0.5. There was a statistically significant difference between all groups (p<0.05). Moreover, a significant correlation between the duration of symptoms and the stage was found (r=0.45, p<0.05). Six patients (67%) of group I were treated arthroscopically. In three patients (33%) primary open debridement and jet lavage were performed. The number of surgical procedures per patient in group I (1.2±0.4) was significantly lower compared to groups II and III (p<0.05). Of group II one was treated arthroscopically, receiving two further revisions. In two (20%) stage III cases, arthroscopy was converted to open debridement within the first session. A primary open surgical debridement was performed in seven (70%). In two patients with joint replacement the primary attempt for implant preservation was made. Due to persisting infection the prostheses were entirely removed during the third revision in both patients. Temporary wound coverage using VAC was performed in eight (80%). Overall 4.4±2.1 surgical procedures per patient were performed in group II. In group III arthroscopic lavage was performed in one. The remaining 23 (96%) received open surgery. In two an attempt to preserve the prosthesis was made whereas following the fifth and sixth operations respectively, secondary implant removal was performed. In nine patients the implant had to be removed primarily. Three patients were treated with inverse prosthesis after six months, two received total joint replacement and three were treated with resection arthroplasty. Patients of group III needed 4.6±1.9 revisions.

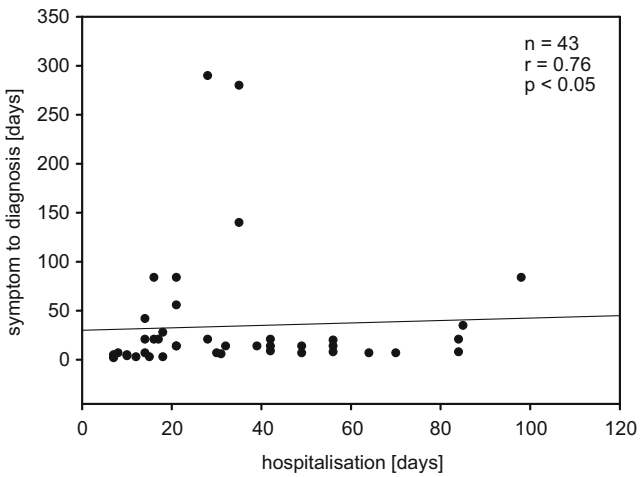

Fig. 3 Correlation between duration of symptoms and duration of hospitalisation

Follow-up

The mean duration of follow-up was 26±7 months. The mean self-assessed Constant score [2] was 74±9 points for the affected shoulder and 84±5 points for the nonaffected shoulder in group I, 63±14 points (affected) versus 85±3 points (nonaffected) in group II, and 53±14 points (affected) versus 75±7 points (nonaffected) for group III. Patients of groups I and II presented with a significantly better outcome in comparison to patients of group III (p<0.05).

Discussion

This study is one of the larger surveys analysing the diagnostic and therapeutic treatment of septic arthritis of the shoulder. We report a series of 43 patients enrolled between 2001 and 2006.

The mean age was 66±12 years and comorbidities were present in 88% of patients. This is a slightly older cohort compared to previous studies [3, 16]. With regard to comorbidities we found at least one risk factor in 88% of patients involving joint infections (renal failure, diabetes, malignancy, alcoholism, systemic immunosuppressive therapy, obesity, and nicotine abuse). This notion is supported by several other authors, reporting a prevalence of comorbidities of up to 87% [3, 9].

A delay in diagnosis plays a crucial role in the outcome of shoulder infections. We demonstrated a significant correlation between the time from the first symptoms to the subsequent duration of hospitalisation. Moreover, patients of groups I and II with an interval of <10 days before diagnosis had a significantly better outcome regarding the Constant score. This finding is supported by Leslie et al. who reported poor results in 90% of patients diagnosed at four weeks [8]. However, a delay in diagnosis of four weeks is unacceptable.

The reason for delay is that septic conditions of the shoulder are not easily identified, since this joint is well covered by soft tissues and not accessible to direct palpation. We observed pain, discomfort, or limitation of motion range in all patients, but other typical signs of infection were only found in a few patients in the early stages. This corresponds to the observations of Pfeiffenberger et al. who reported painful movement restrictions in all of their 28 cases of infected shoulder joints [11]. Ambacher et al. also reported that swelling, redness, and local warming as further typical signs of inflammation were only detected in 60% of their cases [1]. Mean body temperature in our cohort was 39±2°C in group I, 37±1°C in group II, and 36±2°C in group III; thus an absent fever also might not be a sensitive parameter.

All patients showed increased CRP. This is in line with other authors. Mehta et al. reported about 95% of his patients having increased CRP values with a mean CRP value of 15.2 mg/dl [10]. In contrast, an increase of leucocytes >11,000/ml is not a significant parameter. Mehta et al. reported that 42% of his patients showed a WBC <10,000/ml [10]. In all joint aspirates performed in our study, the WBC was >30,000/ml. The diagnostic value of diagnostic joint aspiration has been previously emphasised by several authors [4, 9].

Although radiographs only provide important clues in the late phase of disease, they are mandatory for documentation. Joint aspiration should be performed even in cases without ultrasound proven effusion. In patients with osteosynthesis/prosthesis a CT examination seems to be valuable. Patients with suspicion of concomitant septic spread should also undergo a CT exam. MRI may be helpful in cases of chronic infections as well as septic spread [6, 15]; scintigraphy is rated similarly.

In our series *S. aureus* was found to be the causative organism in 27 of 38 cases. All patients with exogenic infection, suffering from organisms other than *S. aureus*, had received the potential inoculation in a hospital setting. Initiation of antibiotic treatment prevented identification of the organism in five patients. The preponderance of gram-positive *cocci* in our series confirms the need for empirical antibiotic coverage for *S. aureus*. Moreover, in our series the retrospective analysis of antibiotic sensitivities revealed that 34 (79%) patients would have been treated adequately with cefuroxime. Although MRSA was identified in only two (5%) patients, it should be noted that MRSA is gradually emerging and has been recently reported with a prevalence of up to 17% [3]. With regard to the choice of antibiotic, a multidisciplinary approach with microbiologists is essential.

Surgical therapy

We observed a significant correlation between duration of symptoms and Gächter [13] staging. Group I patients could be successfully treated by arthroscopy with a significantly lower number of required revisions in comparison to patients of groups II and III. This is in line with Jeon et al. who reported successful arthroscopy Gächter stage I to II [6]. In our study patients by symptoms lasting four to ten days were either treated by open surgery or were converted from arthroscopy to open debridement due to advanced stages (Gächter III). Vispo Seara et al. also had to treat one stage II and one stage III patient each with open surgery for their revisions [14]. Although the small number of patients retaining prostheses does not require statistical comment in this study, the preservation of prostheses in patients with duration of symptoms more than four days and corresponding intraoperative findings still seem to be critical. In contrast, Jerosch and Schneppenheim emphasise in cases of a gram-positive germ spectrum or an early infection four to six weeks after primary implantation that a preservation of the implant might be possible [7]. When addressing the infected implant with implant-saving surgery, it seems to be essential to clean the 'dead space' between the modular parts of the implant. Especially at the head–shaft connection, there are considerable cavities with some prostheses which appear unfavourable. The authors report here two patients with duration of symptoms of four weeks with a preservation of the prosthesis. However, in patients with duration of symptoms of more than four weeks the authors performed a primary prosthesis removal as well. Treatment with a new prosthesis implantation free of infection is the supreme goal which should be assured via a series of three consecutive negative microbiological reports as well as an adequate time frame without clinical and laboratory infection parameters. Recently developed specific antibiotic sensivity-adapted bone cements should certainly advance progress in this area.

References

1. Ambacher T, Esenwein S, Kollig E, Muhr G (2001) The diagnostic concept of acute infection of the shoulder joint. Chirurg 72:54–60
2. Boehm D, Wollmerstedt N, Doesch M, Handwerker M, Mehling E, Gohlke F (2004) Development of a questionnaire based on the Constant-Murley-score for self-evaluation of shoulder function by patients. Unfallchirurg 107:397–402
3. Cleeman E, Auerbach JD, Klingenstein GG, Flatow EL (2005) Septic arthritis of the glenohumeral joint: a review of 23 cases. J Surg Orthop Adv 14:102–107
4. Gelberman RH, Menon J, Austerlitz MS, Weisman MH (1980) Pyogenic arthritis of the shoulder in adults. J Bone Joint Surg Am 62:550–553
5. Goldenberg DL (1998) Septic arthritis. Lancet 351:197–202
6. Jeon IH, Choi CH, Seo JS, Seo KJ, Ko SH, Park JY (2006) Arthroscopic management of septic arthritis of the shoulder joint. J Bone Joint Surg Am 88:1802–1806
7. Jerosch J, Schneppenheim M (2003) Management of infected shoulder replacement. Arch Orthop Trauma Surg 123:209–214
8. Leslie BM, Harris JM III, Driscoll D (1989) Septic arthritis of the shoulder in adults. J Bone Joint Surg Am 71:1516–1522
9. Lossos IS, Yossepowitch O, Kandel L, Yardeni D, Arber N (1998) Septic arthritis of the glenohumeral joint. A report of 11 cases and review of the literature. Medicine (Baltimore) 77:177–187
10. Mehta P, Schnall SB, Zalavras CG (2006) Septic arthritis of the shoulder, elbow, and wrist. Clin Orthop Relat Res 451:42–45
11. Pfeiffenberger J, Meiss L (1996) Septic conditions of the shoulder—an up-dating of treatment strategies. Arch Orthop Trauma Surg 115:325–331
12. Rispoli DM, Sperling JW, Athwal GS, Schleck CD III, Cofield RH (2007) Pain relief and functional results after resection arthroplasty of the shoulder. J Bone Joint Surg Br 89:1184–1187

13. Stutz G, Kuster MS, Kleinstuck F, Gachter A (2000) Arthroscopic management of septic arthritis: stages of infection and results. Knee Surg Sports Traumatol Arthrosc 8:270–274
14. Vispo Seara JL, Barthel T, Schmitz H, Eulert J (2002) Arthroscopic treatment of septic joints: prognostic factors. Arch Orthop Trauma Surg 122:204–211
15. Weishaupt D, Schweitzer ME (2004) MR imaging of septic arthritis and rheumatoid arthritis of the shoulder. Magn Reson Imaging Clin N Am 12:111–124
16. Wick M, Muller EJ, Ambacher T, Hebler U, Muhr G, Kutscha-Lissberg F (2003) Arthrodesis of the shoulder after septic arthritis. Long-term results. J Bone Joint Surg Br 85:666–670