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ORIGINAL PAPER

Septic arthritis due to streptococci and enterococci in native joints: a 13 year retrospective study

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Abstract

Objectives Streptococcal species are the second most common cause of native joint septic arthritis (SA). However, there are few systematic data about streptococcal SA.

Methods The medical records of adults with SA caused by streptococci, pneumococci, and enterococci at our tertiary care centre between 2003 and 2015 were reviewed.

Results 71 patients (34% female) with 83 affected joints were included. Median age was 62 years. A single joint was involved in 62 patients (87%). One or more comorbidities were present in 58 patients (82%). 16 patients (23%) had a concomitant soft-tissue infection overlying the affected joint. The hematogenous route was the dominating pathogenesis (42/71, 59%). 9 (13%) patients were diagnosed with endocarditis. The knee was the most commonly affected joint (27/83, 33%) followed by shoulder (13/83, 16%). ß-haemolytic streptococci were most commonly identified (37/71, 52%) followed by polymicrobial infections (12/71, 17%). Surgical interventions included arthroscopic irrigation and debridement in 31 (44%), arthrotomy in 23 (32%), and amputation in five patients (7%). Median duration of antimicrobial therapy was 42 days. Antibiotic treatment without any surgical intervention was performed in 5 (7%) patients. Outcome was good in 55 (89%) patients; mortality was 13% with four of nine deaths attributed to joint infection. Age and pathogen group independently predicted poor outcome in recursive partitioning analysis.

Conclusions Streptococcal SA was mostly due to ß-haemolytic streptococci in older and polymorbid patients. Old age, anginosus group streptococci, enterococci, and polymicrobial infections predicted poor outcome, while antibiotic treatment duration can likely be shortened.

Keywords Septic arthritis · Bacterial arthritis · Joint infections · Streptococci · Enterococci

Introduction

Streptococcal species are the second most common cause of native joint septic arthritis (SA) with considerable morbidity and mortality [1–3]. The reported incidences range from 7 to 12 per 100′000 persons in the general population with peaks in elderly, immunocompromised and those with pre-existing joint damage [3–5]. Besides, there seems to be a recent increase in incidence [3–6]. However, there are few systematic data about streptococcal joint infections. To systematically examine these infections and identify differences between streptococcal species, we retrospectively analysed clinical and laboratory data from all patients with streptococcal and enterococcal SA who were seen at our center over 13 years.

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Helene Lotz and Carol Strahm have contributed equally to this work.

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Materials and methods

All patients ≥ 18 years diagnosed with streptococcal SA between 2003 and 2015 at the Cantonal Hospital St. Gallen, a tertiary care teaching hospital with 833 beds, were included in this retrospective chart review. Patients were identified through database searches of Orthopaedic Surgery, Infectious Diseases, and the Microbiology Department. Inclusion criteria were detection of streptococci, pneumococci, or enterococci from positive culture or with broad-range 16S ribosomal ribonucleic acid gene PCR as previously described [7] from either synovial fluid or intra-operative biopsies, or from blood cultures in combination with clinical signs of SA. SA was defined by clinical criteria, i.e., erythema, warmth, swelling, pain, or limited function, plus either at least one of elevated cell count, frank pus, positive culture or PCR from synovial fluid or bacteremia. Mixed infections of streptococcal species, pneumococcus, or enterococcus were included; infections by anaerobic streptococci and prosthetic joints infections were excluded.

Data on clinical presentation, laboratory results, microbiology, treatment, and outcome were retrospectively collected from medical records. Articulations of the hand and foot were defined as small joints, and wrist and ankle as intermediate, whereas sacroiliac, acromioclavicular and sternoclavicular as axial joints, all others as large joints.

The length of intravenous antibiotic treatment was determined clinically in concordance with signs of local inflammation of involved joints, the presence of fever (provided the fever was present in 21% of patients), of general status, of stay in the intensive unit care, as well as of laboratory criteria and the necessity of repeated surgical treatment.

Arthrotomy included either open irrigation or debridement or both.

Outcome was classified based on local findings, inflammatory laboratory parameters and joint functionality. We distinguished between full recovery and poor outcome, which was defined as either all-cause death, amputation or exarticulation, poor joint function or requirement for chronic suppressive antibiotic therapy. Assessment of joint function was based on discharge reports, rehabilitation reports, and regular follow-up examinations 2 and 6–8 weeks after discharge.

Descriptive statistics for continuous data included median, range, and standard deviation, whereas categorical data were described with counts and proportions. To compare proportions, Chi-square test or Fisher's exact test was applied, as appropriate. *P* values of < 0.05 were considered significant for all analyses. Statistical analysis was performed with R (R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.r-project.org/). Recursive partitioning analysis (R-package 'rpart') was used to create a decision tree. Patients were split into subpopulations based on several independent predictors. Our decision tree aimed to identify predictors (pathogen, risk factors, number and size of affected joints, antibiotic duration, and surgical interventions) which predicted outcome.

The study was approved by the local Ethics Committee (EKSG 15/161). Due to the retrospective nature of the study, an informed consent was waived.

Results

Epidemiology

Overall, 71 adults (24 women [34%], median age 62 (range: 19–88) years) with 83 infected native joints caused by streptococci, pneumococci, and enterococci were identified. At least one comorbidity was present in 82% (Table 1), most commonly renal insufficiency ($n = 22$, 31%), heart failure ($n = 22$, 31%), and diabetes ($n = 21$, 30%). Joint-associated predisposing factors were frequent with chronic arthropathy in 49 (59%), arthrocentesis in 10 (12%), and joint injury in 19 (23%) of 83 involved native joints. A single joint was involved in 62 (87%) patients. The lower extremities, particularly the knees, were most commonly affected (Fig. 1; Table 2).

Pathogens

In 12 of 71 patients (17%), SA was caused by polymicrobial infections. In case of monomicrobial infection, ß-haemolytic streptococci were the most commonly identified streptococcal group (37/71, 52%), *Streptococcus pneumoniae* (9/71, 13%), and viridans group streptococci (6/71, 8%) (Fig. 1).

The 7 of 10 identified serotypes of pneumococci were 7F ($n = 2$), 3 ($n = 1$), 12 F ($n = 1$), 15A ($n = 1$), 22F ($n = 1$), and 23F ($n = 1$).

Viridans group streptococci, *Streptococcus bovis/gallolyticus*, anginosus group streptococci, enterococci, and polymicrobial infections always affected one joint only, while pneumococci (4/9) and β-haemolytic streptococci (13/37) also involved multiple joints. Enterococcal species caused SA among three patients as a single pathogen and among four patients in polymicrobial infections.

18 of 37 patients (49%) with ß-haemolytic streptococci (*S. pyogenes* [$n = 3$], *S. agalactiae* [$n = 6$] and *S. dysgalactiae* [$n = 9$]) had an additional extra-articular manifestation (pneumonia, endocarditis, (distant) skin and soft-tissue infection, otitis, meningitis, and osteomyelitis) compared to 15 of 34 patients (44%) with all other streptococci ($p = 0.7$),

Table 1 Clinical findings and demographic characteristics of 71 patients with 83 affected native joints

Characteristics or findings	
Patients, no (%)	71 (100%)
Age, years	
Median (+/− IQR)	62 (54/76.5)
19–59	25 (35%)
60–79	32 (45%)
≥ 80	14 (20%)
Sex	
Female	24 (34%)
Comorbid conditions and risk factors	
Rheumatoid arthritis	1 (1%)
Corticosteroid use	2 (3%)
HIV infection	1 (1%)
Malignancy	15 (21%)
Transplantation	1 (1%)
Neutropenia	1 (1%)
Connective tissue disease	4 (6%)
Otherwise immune suppression	5 (7%)
Heart failure	22 (31%)
COPD	9 (13%)
Liver disease	13 (18%)
Alcoholism	15 (21%)
Kidney failure	22 (31%)
Diabetes mellitus	21 (30%)
Gout	5 (7%)
Intravenous drug use	9 (13%)
No comorbidity	13 (18%)
Chronic arthropathy[a]	49 (59%)
1 Joint involved	62 (87%)
≥ 2 joints involved	9 (13%)
Injury of joint[a]	19 (23%)
Prior joint surgery[a]	7 (8%)
Prior arthrocentesis[a]	10 (12%)
Mortality rate	9 (13%)
Cause of mortality	
Arthritis	4 (6%)
All other causes	5 (7%)

IQR interquartile range, *COPD* chronic obstructive pulmonary disease

[a]Referring to number of involved joints ($n = 83$)

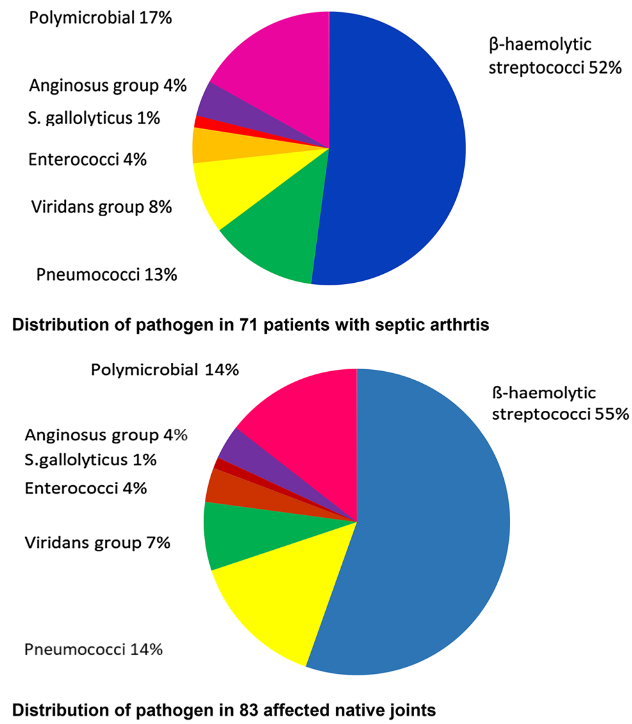


Fig. 1 Pathogen distribution in 71 patients with septic arthritis caused by streptococci, pneumococci, and enterococci with 83 native joints involved

Table 2 Distribution of 83 native joints with septic arthritis caused by streptococci, pneumococci, and enterococci

Joint(s) involved	$n = 83$
Large joints	
Knee	27 (33%)
Shoulder	13 (16%)
Hip	5 (6%)
Elbow	2 (2%)
Intermediate joints	
Wrist	9 (11%)
Ankle	8 (10%)
Small joints	
Foot	8 (10%)
Finger	5 (6%)
Axial joints	
Sternoclavicular	4 (5%)
Acromioclavicular	1 (1%)
Sacroiliac	1 (1%)

and 6 of 9 (67%) ($p = 0.2$) with pneumococcal and 2 of 3 (67%) ($p = 0.5$) with enterococcal SA.

In 42 of 71 patients (58%), SA presumably developed hematogenously in nine patients with endocarditis (13%), infected vascular catheter 4 (6%), pneumonia 1 (1%), osteomyelitis 4 (6%), remote soft-tissue infection 11 (16%), or another distant source. The most common site of entry was a soft-tissue infection overlying the affected joint in 16 patients (23%). Blood cultures were obtained in 60 of 71 patients (85%) and were positive in 32 patients (53%). 22 (69%) of bacteraemic patients had an associated extra-articular focus. Septic arthritis presumably developed from a contiguous soft-tissue infection in 16 patients (23%). The pathogenesis was unknown in 14 cases (20%); however, bacteraemia without endocarditis was present in 4 of those (*S.*

agalactiae, $n=2$; *S. pneumoniae*, $n=1$; *S. bovis/gallolyticus*, $n=1$).

A third of patients with polymicrobial infections (4/12) developed hematogenously and 3 of 12 patients (25%) had joint injury. None of them developed SA iatrogenic after a previous arthrocentesis.

Clinical and laboratory findings

Hypothermia (≤ 36 °C) or fever (≥ 38.5 °C) were present in only 10 (14%) and 15 (21%) patients on presentation, respectively (Table 3). 13 of 14 (93%) patients ≥ 80 years old did not have a fever.

A diagnostic aspiration was performed in 58 (70%) of 83 joints and in 50 (70%) of 71 patients. Median WBC in the synovial fluid was 76.8 (range 9.3–365.9) G/L with predominance of polymorphonuclear neutrophils (PMN) (median 93%, range 64–100%) when analysed ($n=25$; supplemental table). The sensitivities of different cut-offs were 88% (22/25) for WBC ≥ 25G/L, 64% (16/25) for WBC ≥ 50 G/L and 44% (11/25) for WBC ≥ 100 G/L; neutrophil granulocytes were ≥ 90% in 62% (13/21).

Gram staining of synovial fluid was positive in 59% (34/58) and eubacterial PCR was positive in 96% (22/23, Fig. 2b). Cultures from joint fluids were positive in 79% (46/58). In patients with positive synovial cultures, the same pathogen was detected in blood cultures in 60% (25/42).

56 of 69 joint biopsies (81%) collected during the first operation were culture-positive. Of those, only a single sample was positive in 24 (43%); > 1 were positive in the remaining 32 biopsies (57%). 17 of culture-positive patients and all culture-negative patients received antimicrobial treatment at sample collection, respectively ($p<0.01$).

Patients with negative intraoperative cultures had either positive blood cultures in 77% (10/13, Fig. 2a) or positive eubacterial PCR from joint biopsy in 23% (3/13, Fig. 2c). Eubacterial PCR from biopsies was available from 35% (24/69) of joints.

Table 3 Laboratory findings of 71 patients with 83 affected native joints

Bacteraemia	32 (45%)
With another extra-articular infection	22 (31%)
Without another extra-articular infection	10 (14%)
Temperature median (min/max) (°C)	37.3 (32.7/40.2)
≤ 36.0 °C	10 (14%)
≥ 38.5 °C	15 (21%)
WBC median (+/-IQR)	10.7 (8.2/15.3)
WBC count ≤ 4×10^9/L	1 (1%)
WBC count ≥ 10×10^9/L	39 (55%)
Thrombocytes median (+/-IQR)	207.5 (138.5/287.75)
CRP median (min/max)	226.0 (3/587)

Antimicrobial management

Median duration of antibiotic therapy in 60 of 62 surviving patients was 42 (range 15–242) days (Table 4). Two patients received long-term antibiotic suppression for > 365 days; in one, antimicrobial treatment was not stopped after 3 months as recommended by infectious diseases consultation; in the other chronic suppression therapy was given for a pacemaker-associated endocarditis without pacemaker removal. Intravenous antibiotics were given for a median of 32 (range 5–159) days followed by oral antibiotics for a median of 14 (range 0–83) days. 20 patients had intravenous treatment only. Antibiotics were given for a median of 29 (range 0–98) days after the last operation. Patients with small joint SA received a shorter antibiotic treatment: intravenous antibiotics for a median of 21 (range 5–43) days ($p=0.02$) versus 35 (range 12–159) days ($p<0.001$) for large joint SA, respectively. Oral therapy lasted for a median of 10 (range 0–67) days ($p=0.2$) for small joint SA and for a median of 14 (range 0–83) days ($p=0.81$) for large joint SA. The duration of total antibiotic therapy was for a median of 35 (range 18–92) days ($p=0.2$) for small joint SA and for a median of 45 (range 19–242) days in large joint SA ($p=0.001$).

The values for patients with intermediate joint SA were: intravenous therapy for a median of 26 (range 15–39) days ($p=0.08$), oral for a median of 7 (range 0–29) days ($p=0.16$), and total for a median of 31 (range 23–59) days ($p=0.02$). Antibiotic therapy was longest in patients with SA caused by viridans group streptococci, followed by those with *S. pneumoniae* and ß-haemolytic streptococci (Table 5; Fig. 3).

Surgical management

Most patients (66/71; 93%) had at least one surgical intervention, only five were treated conservatively with antibiotic management alone without any surgical therapy or arthrocentesis. In total, 172 interventions (arthroscopic irrigations; arthrotomies; amputations) were performed (mean 2.3, range 0–9). Arthroscopic irrigation and debridement was mainly performed in knees (26/27 [96%]), shoulders (11/13 [85%]), and ankles (5/8 [63%]), while hip was mainly treated by open irrigation and debridement (4/5 [80%]). However, in two knees and three shoulders treated by arthroscopy initially, an arthrotomy was subsequently performed because of persistent infection.

21 patients had only one surgical intervention. Of 45 patients with > 1 intervention, 23 patients had 2 interventions (the second intervention was in the same technique in all but 3 patients who had conversion from arthroscopic to open revision), and 22 patients had > 2 interventions (from 3 to 8, median 3). Among 5 patients with amputations, 3 patients had polymicrobial diabetic foot infections and one

each *S. agalactiae* and *S. anginosus* group. Good outcome was observed both in 24 of 31 patients with only arthroscopy and in 20 of 28 patients with only arthrotomy as well as in all 7 patients with combined surgical treatment (arthroscopy and arthrotomy) (Table 4).

Clinical course during hospital stay

Median length of hospital stay was 28 (range 5–163) days (including one death on day 5). 20 patients (28%) were admitted to the intensive-care unit (ICU) for a median of 13 (range 1–107) days. Patients with both viridans group streptococci, *S. bovis / gallolyticus* and with polymicrobial infections (except for one patient with *S. pneumoniae*/*S. pyogenes* co-infection) did not present with sepsis.

Follow-up and outcome

Mean follow-up of the 62 survivors until discharge was 88 (range 12–509) days. Outcome was good in 55/62 (90%). Mortality in our cohort was 13% (9/71). 4 deaths were attributed to uncontrolled infection with *S. dysgalactiae* ($n=2$), *S. pneumoniae* ($n=1$), and *S. pneumoniae*/ *S. pyogenes* ($n=1$) co-infection. The other five deaths were not SA-related.

In five patients without surgical intervention, outcome was good except for one patient who developed chronic osteomyelitis. 8 of 62 survivors (13%) developed osteomyelitis, five of which due to ß-haemolytic streptococci.

Risk factors for poor outcome

Using recursive partitioning analysis, only age and pathogen group independently predicted poor outcome. The strongest risk factor was age ≥ 62.5 years followed by presence of either anginosus group streptococci, enterococci, or polymicrobial infection (Fig. 4). Among all 71 patients, a good outcome was present in 32 (88.9%) of 36 aged < 62.5 years, but only in 23 (65.7%) of 35 aged ≥ 62.5 years ($p=0.02$). Among the 35 patients ≥ 62.5 years, outcome was good in 21 of 27 patients (77.8%) if pathogens included *S. dysgalactiae*, GAS, GBS, pneumococci, or viridans group streptococci, but only in 2 of 8 (25%) if they had either anginosus group streptococci, enterococci, or polymicrobial infection ($p=0.01$).

Discussion

Our study identified 71 patients with native joint arthritis by streptococci and enterococci over a period of 13 years. Patients were older; most had comorbidities including pre-existing joint damages or manipulations and usually underwent at least one surgical intervention. The mean antimicrobial treatment duration (42 days) was longer than expected.

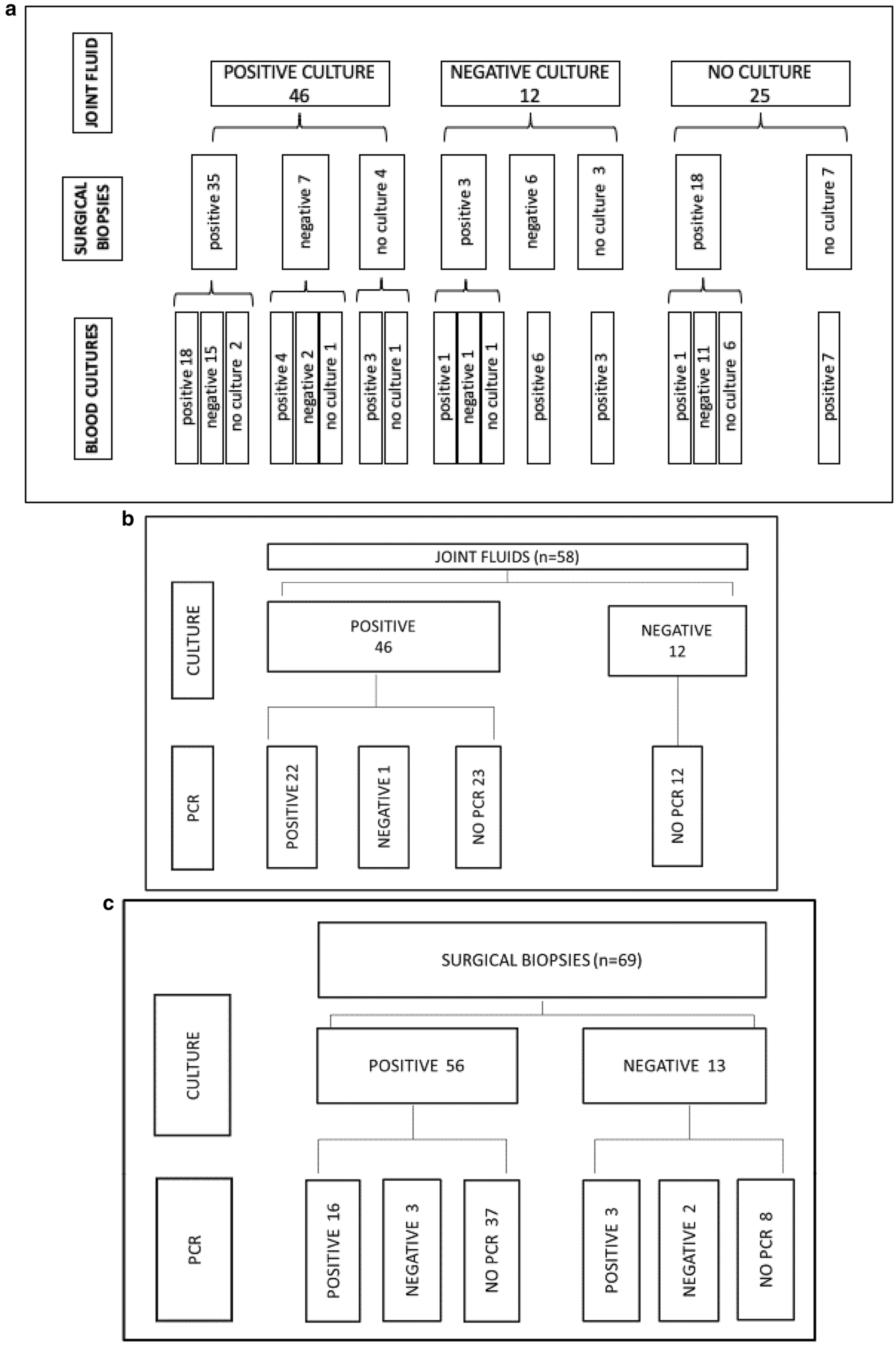
Recent data about streptococcal arthritis are rare. Existing studies are older [8], focus on β-haemolytic streptococci [9–11] and pneumococci [12], or are case reports of viridans group streptococci [13]. In our cohort, β-haemolytic streptococci represented more than half the cases, followed by pneumococci (10%) and viridans group streptococci. Enterococci, *S. gallolyticus* and anginosus group streptococci were rarely involved in monomicrobial infections. Nearly 20% of infections were polymicrobial, which usually represented small joint arthritis in diabetic foot infections developing *per continuitatem* from an overlying malum perforans.

Interestingly, only about one-third of patients presented with fever or hypothermia, even though more than 50% of infections were caused by highly virulent β-haemolytic streptococci. Fever was reported less frequent in non-gonococcal SA, but more commonly for β-streptococci (58–88%) and pneumococci (65%) [10, 14–16]. This underscores the importance to clinically suspect and rule out SA even in absence of fever with any unclear inflammatory condition. Unfortunately, the use of analgesic therapy as a potential explanation for the absence of fever was not assessed in this study. In agreement with the lower likelihood of fever in the elderly [17], fever was almost universally absent in older patients.

In accordance with the previous reports, in most of cases (57%), infection involved a single large joint, particularly the knee [1, 3, 6, 8, 15]. Enterococcal species were the only isolated pathogen or in combination with other pathogens in the small joints of foot or of hand [1]. However, in 13% and only in infections due to pneumococci or β-haemolytic streptococci, two and more joints were infected. The oligoarticular involvement of SA due to β-haemolytic streptococci and pneumococci is well known, and probably reflects their expression of virulence factors and tropism for joints [8, 15, 16, 18–20]. In nearly 50% of patients, an extra-articular manifestation (mostly soft-tissue infections) was found [8].

In concordance with the previous studies, SA mostly developed hematogenously [1, 3, 4, 6, 15, 21–24], followed by contiguous spread from soft-tissue infection. However, the final pathogenesis often remained unclear similar to other cohorts [8]. Blood cultures taken from 85% of patients were positive in about half of cases. 13% of patients had concomitant endocarditis [8, 25], which should always be searched for in streptococcal or enterococcal SA. The dental status of patients was not systematically elaborated; however, oral-dental pathogenesis was considered in 4 patients (6%) within our cohort and was previously described especially in viridans group SA [8, 13, 26] but postulated rarely in GBS SA [20, 27].

Arthrocentesis with determination of synovial fluid count and percentage of PMNs is the most powerful tool to


a
JOINT FLUID
POSITIVE CULTURE 46
NEGATIVE CULTURE 12
NO CULTURE 25
SURGICAL BIOPSIES
positive 35
negative 7
no culture 4
positive 3
negative 6
no culture 3
positive 18
no culture 7
BLOOD CULTURES
positive 18
negative 15
no culture 2
positive 4
negative 2
no culture 1
positive 3
no culture 1
positive 1
negative 1
no culture 1
positive 6
positive 3
positive 1
negative 11
no culture 6
positive 7
b
JOINT FLUIDS (n=58)
CULTURE
POSITIVE 46
NEGATIVE 12
PCR
POSITIVE 22
NEGATIVE 1
NO PCR 23
NO PCR 12
c
SURGICAL BIOPSIES (n=69)
CULTURE
POSITIVE 56
NEGATIVE 13
PCR
POSITIVE 16
NEGATIVE 3
NO PCR 37
POSITIVE 3
NEGATIVE 2
NO PCR 8

◂**Fig. 2** **a** Results of cultures taken from aspirated synovial fluid, of cultures taken from surgical biopsies of 83 affected native joints, and results of blood cultures of 71 patients with native septic arthritis caused by streptococci, pneumococci, and enterococci. **b** Results of PCR and cultures taken from aspirated synovial fluid in 58 of 83 affected joints. **c** Results of PCR and cultures of surgical biopsies of 69 of 83 affected joints collected during the first operation

diagnose SA [14]. In our cohort, the sensitivities of a PMN cut-off of 25 G/L was 88% (22/25), cut-off of > 50 G/L, and percentage of PMN of > 90% were 64% (16/25) and 62% (13/21), respectively, which was similar to published values [14]. Gram stain of synovial fluid was positive in 59%, which assists rapid diagnosis and narrowing empirical treatment after arthrocentesis. This was in accordance with the literature, where Gram stain positivity was reported as high as 72% in streptococcal arthritis [8], and between 50–70% in non-gonococcal arthritis [28]. However, diagnostic value of Gram stain was questioned being as low as 29% in the largest single-center study [29].

Culture is necessary for pathogen identification and antibiotic susceptibility testing [30]. PCR was only performed selectively and was mainly helpful in patients receiving antibiotics when cultures were obtained.

There are no controlled studies about optimal treatment duration in septic arthritis [31]. For streptococci, expert opinions propose a total treatment duration between 2 and 6 weeks, and there is no consensus about IV treatment duration [15, 21, 24, 32]. Recommended treatment durations for streptococcal SA vary from 2 [6, 24, 33] up to 6 weeks [21, 24, 33–35] and for pneumococcal SA 3–4 weeks [15, 36]. In our cohort, mean treatment duration was about 6 weeks. However, in recursive partitioning analysis, short treatment was not predictive for poor outcome. We, therefore, speculate that our antibiotic treatment could be safely shortened in at least some patients.

Since most articles describe the treatment of arthritis caused by streptococci without subdivision into various subtypes, comparison of our data with the literature is difficult, particularly regarding the different species and intravenous and oral antibiotic applications.

In acute SA removal of pus is the cornerstone for successful treatment [21, 32]. Arthroscopic irrigation as initial

Table 4 Antimicrobial treatment in 60 of 62 surviving patients (long-term antibiotic suppression for > 365 days excluded) and surgical treatment of 71 patients with native joint septic arthritis caused by streptococci, pneumococci, and enterococci

Antimicrobial treatment	*n* = 60 (death and suppression excluded)	Good outcome (*n* = 55)	Poor outcome (*n* = 16)*
Total duration median (min/max)	42 days (15/242)		
Intravenous median (min/max)	32 days (5/159)		
Intravenous only	20 (30%)		
Oral median (min/max)	14 days (0/83)		
Oral only	–		
Surgical treatment	*n* = 71*		
Arthroscopy only**	31 (44%)	24	7**
Arthrotomy only***	28 (39%)	20	8***
Combined	7 (10%)	7	–
Number of procedures (mean, range)	2.3 (0–9)		
Conservative treatment	5 (7%)	4	1

*9 deaths included **6 deaths included ***3 deaths included

Table 5 Duration of antibiotic therapy in 69 of 71 patients (long-term antibiotic suppression for > 365 days excluded) with native joint septic arthritis caused by streptococci, pneumococci, and enterococci according to pathogen

Organism	Treatment intravenous, days median (range)	Treatment oral, days median (range)	Total duration of antibiotic therapy, days, median (range)
S. pneumoniae (*n* = 9)	23 (3, 107)	13 (0, 29)	41 (3, 107)
β-haemolytic streptococci (*n* = 36)	34 (5, 159)	8 (0, 83)	40 (15, 242)
Viridans group streptococci (*n* = 6)	32 (14, 43)	21.5 (7, 32)	51.5 (25, 65)
S. bovis/gallolyticus (*n* = 1)	28 (28, 28)	0	28 (28, 28)
S. anginosus group (*n* = 3)	28 (26, 29)	8 (0, 14)	34 (29, 42)
Enterococci (*n* = 3)	32 (26, 44)	0	32 (26, 44)
Polymicrobial (*n* = 11)	27 (15, 54)	10 (0, 72)	33 (18, 126)

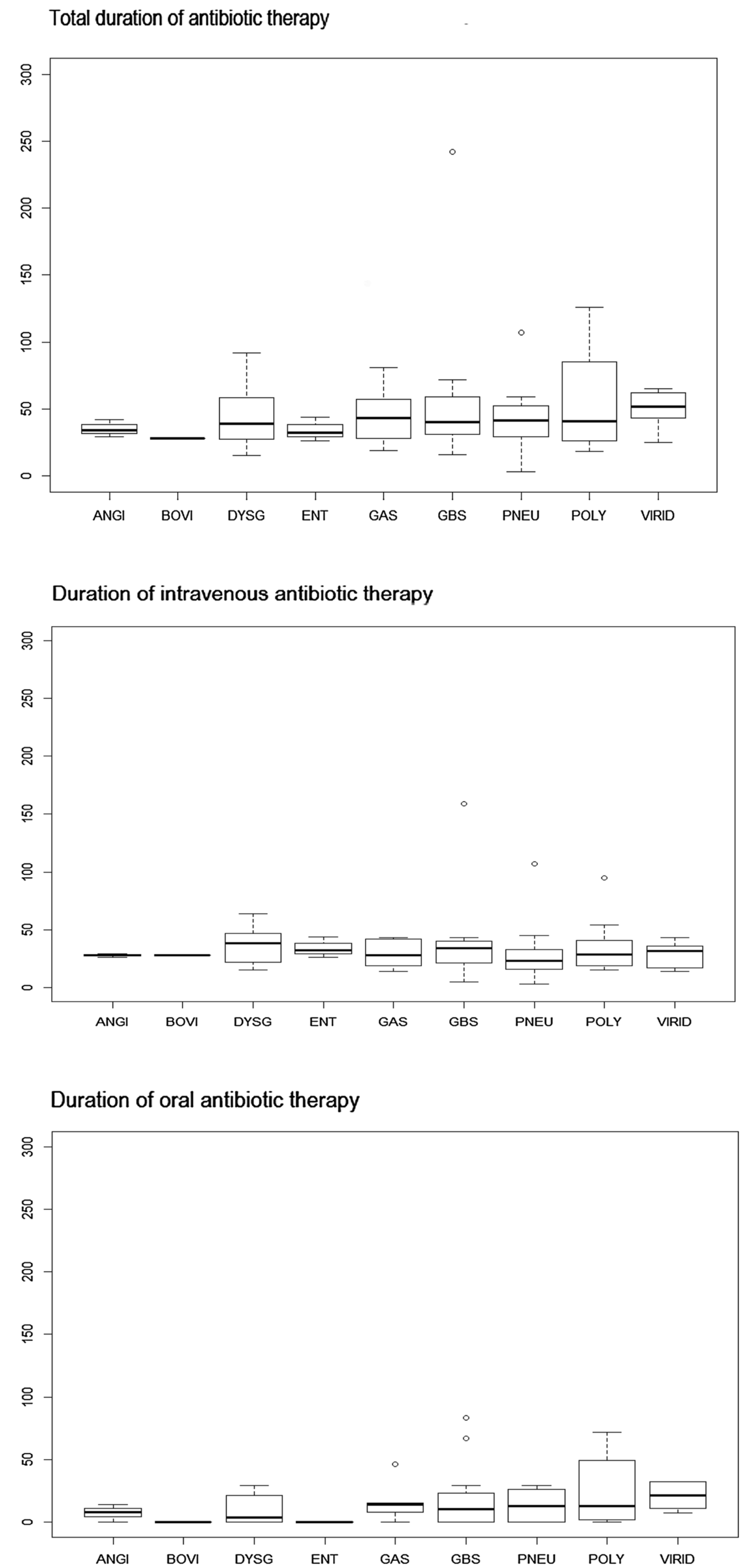


Fig. 3 Duration of antibiotic therapy in 69 of 71 patients (long-term antibiotic suppression for > 365 days excluded) with native joint septic arthritis caused by streptococci, pneumococci, and enterococci according to pathogen. *ANGI* S. anginosus group, *BOVI S. bovis/S. gallolyticus, DYSG S. dysgalactiae, ENT* enterococci, *GAS* group a streptococci, *GBS* group b streptococci, *PNEU S. pneumoniae, POLY* polymicrobial, *VIRID* viridans group streptococci

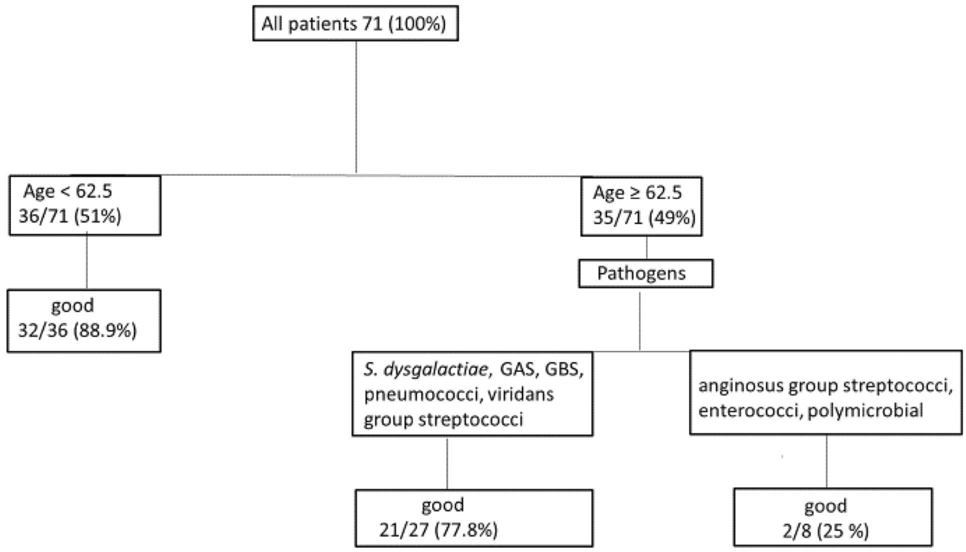


Fig. 4 Results of recursive partitioning analysis, based on independent predictors to identify predictors (pathogen, risk factors, number and size of affected joints, antibiotic duration, and surgical interventions) which predicted outcome in 71 patients with septic arthritis caused by streptococci, pneumococci, and enterococci. *GAS* group a streptococci, *GBS* group b streptococci

treatment is preferred whenever possible [37]. Open debridement is considered after repeated unsuccessful arthroscopic interventions or in advanced stages of infection [34, 38]. About one-third of our cases had a single intervention only, while one-third had 2 interventions and one-third had even > 2 interventions following the suggestion to repeat drainage until pus no longer accumulates [21]. However, there are scant data in the literature to compare our experience. In streptococcal arthritis, conservative treatment is often reported as successful [8, 10, 16, 18–20] and often one irrigation as sufficient [10]. Conversion from arthroscopic to open debridement was rarely necessary and outcome was independent of type of surgery in our cohort.

Few (5) patients were treated without intervention, but had good outcome with only one resulting in treatment failure with recurrence and chronic osteomyelitis which was less than previously described in a series of mostly *Staphylococcus aureus* infections [39].

Mortality was 13%, with all but 1 patient aged > 60 years. This is comparable to the mortality of 2–20% in non-gonococcal septic arthritis [1, 21, 23, 40], and to the mortality of 19% associated with pneumococcal arthritis in adults [15]. Accordingly, the recursive partitioning analysis showed poor outcome in the older patients and those with anginosus group streptococci, enterococci, and polymicrobial infections. Interestingly, the patients infected by *S. dysgalactiae*, GAS, GBS, pneumococci, and the viridans group streptococci, which are considered more virulent pathogens, had better outcome than the other aetiologies. Our hypothesis is that the former probably affected young healthy patients and the latter old and polymorbid patients.

Some limitations of our data should be taken into consideration. The information was collected retrospectively from medical records. Despite the long observation period, we only identified 71 patients.

In conclusion, streptococcal SA was mostly due to ß-haemolytic streptococci in old and polymorbid patients with considerable mortality. Old age, anginosus group streptococci, enterococci, and polymicrobial infections were associated with poor outcome. The optimal duration of antibiotic therapy remains unclear, but safety and efficacy of shorter treatment duration should be investigated.

Author contributions The conception and design of the study: HL, CS, and WCA; acquisition of data: HL and CS; analysis of data: HL, CS, and VZ; interpretation of data: all authors; drafting the article: HL, CS, and WCA; critical revision of the article: all authors; final approval of the version to be submitted: all authors.

Compliance with ethical standards

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Ethical approval The study was approved by the local Ethics Committee (EKSG 15/161).

Informed consent Due to the retrospective nature of the study, an informed consent was waived.

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