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Comparison of the results of medical approach and surgical approach of septic arthritis in native joints: a single-center retrospective study

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Abstract

Background The consequences of septic arthritis of natural joints may be devastating. The purpose of this study was to evaluate the functional results of medical approach and surgical approach for septic arthritis of native joints, and to explore whether the number of drainage tubes after arthroscopic surgery will affect the knee function of patients.

Methods A single-center retrospective study was conducted on patients diagnosed with septic arthritis from January 2018 to January 2023. According to the improvement of clinical symptoms and daily activity ability of the joints, functional results of patients were divided into Complete recovery, Basic recovery, Minor recovery and No recovery. The main results are the joint function after medical and surgical approaches. The secondary outcome was knee function with different number of drainage tubes after arthroscopic surgery. Multivariate logistic regression analysis was used to determine the risk factors related to joint function. In addition, the types of bacteria were analyzed to explore whether they were related to the initial surgical failure rate.

Results Among the 77 patients with septic arthritis, 27 patients were treated with medical approach, and 50 patients were treated with surgical approach (knee arthroscopy + synovectomy). There was no significant difference in the results of joint function at discharge and 6 months after discharge. There was no significant difference in the number of drainage tubes after knee arthroscopy on the recovery of knee joint function. There were no risk factors independently associated with joint function outcomes in this study. In the cases of initial surgical failure, the treatment failure rate was 13.0% in the multidrug-sensitive bacteria group, 100% in the methicillin-resistant Staphylococcus aureus group, and 58.3% in the other multidrug-resistant bacteria group ($P = 0.001$).

Conclusions The results of this study indicate that medical methods may be as effective as surgical methods for functional recovery in patients with septic arthritis. The number of drainage tubes after knee arthroscopy had no significant effect on the recovery of knee joint function. Maybe the type of bacteria (gram negative or more aggressive ones) can play a role in the choice of treatment strategy. Further prospective studies with better methodology are needed.

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Keywords Septic arthritis, Arthroscopy, Medical approach, Functional effect

Background

Septic arthritis in native joints is usually rare, but the consequences are very serious, in addition to severe function-related sequelae, and even the risk of amputation and death. The reported incidence is 4-13.28/100,000 [1], and the incidence in Asia seems to be higher in recent years [2]. The incidence of septic arthritis increases at a rate of 2–10 cases per 100,000 people per year, partly due to the aging of the population and the increase in comorbidities [3].

At present, there is no clear guideline for the treatment of adult septic arthritis of native joints. Five professional associations, including the British Society or Rheumatology (BSR), jointly issued guidelines on septic arthritis management in 2006, but did not make clear recommendations on medical and surgical methods [4].

Intravenous broad-spectrum antibiotics is the main medical treatment for septic arthritis in native joints, and many recent studies show the excellent efficacy of medical treatment for septic arthritis [5–7]. However, the medical treatment is not the standard care, which might not be adequate for every patient. Other options for the treatment of septic arthritis in native joints include needle aspirations or surgery with or without instillation of antibiotics (such as arthrotomy, arthroscopic synovectomy and more modern techniques).

Joint irrigation can be done either by needle aspirations or by surgery. In the surgical approach, 0–3 drainage tube can be left. The choice of drainage methods is more based on the experience of physicians, and there is no clear guideline [8].

We aim to compare the prognosis of arthroscopic surgery and medical approach and to explore whether the number of drainage tubes after knee arthroscopy will affect the prognosis of patients. In addition, we also explore whether the drug resistance of the infected bacteria would affect the failure rate of the initial surgery.

Patients and methods

We conducted a retrospective study from January 2018 to January 2023 in a tertiary hospital in Hangzhou, China. According to the International Classification of Diseases, all cases with a diagnostic code of septic arthritis (M00.900) were screened in the Hospital Database, and the cases were screened by inclusion and exclusion criteria. Finally, the diagnosis was determined by a senior chief physician (medical group leader).

According to the different departments selected at admission, these patients were treated in Department of orthopedics, rheumatology, infection diseases and pain. Patients hospitalized in Orthopedics Department were treated with surgical approach, while patients hospitalized in the other three departments were only treated with medical approach.

Inclusion criteria

a. Nonspecific symptoms including joint pain, swelling, fever, limited joint movement and tenderness.
b. Pathogenic bacteria were isolated from synovial fluid culture or blood culture and/or synovial fluid analysis showed a WBC count over 50,000 cells per microliter and a high percentage of polymorphonuclear cells (90% or more).
c. MRI images showed exhibit lamellated synovial thickening patterns, bone marrow edema, or soft tissue abscess formation.
d. Crystal analysis showed that the result of microcrystals was negative.

Exclusion criteria

a. The patient is under 18 years of age.
b. Prosthesis-related septic arthritis.

The demographic characteristics (age, gender), number of comorbidities, organism results, type of antibiotics, duration of intravenous antibiotics, preoperative time, length of hospital stay, and number of postoperative drainage tubes were evaluated.

The main endpoint of the study was the functional outcome of the patient at the time of discharge and 6 months after discharge after adequate medical or surgical treatment. The functional outcome of the patient 6 months after discharge was routine follow-up, which was verified again by telephone follow-up. Patients were divided into 2 groups according to whether they were hospitalized in the department of surgery (orthopedics) or internal medicine (rheumatology, infection diseases and pain).

Synovial fluid was obtained by needle aspiration in patients with septic arthritis of knee joint. If it was other joints, fluid was obtained under B-ultrasound according to MRI results.

The patients from both the medical approach and the surgical approach were treated with empirical antibiotics. After obtaining the results of microbial results, the treatment plan was adjusted according to the antibiotic sensitivity of each microorganism. If the positive culture results cannot be obtained, the antibiotics should be adjusted according to the patient's clinical manifestations, laboratory indicators and doctor's experience.

The patients in the surgical approach underwent arthroscopic surgery (knee arthroscopy+synovectomy) in addition to the use of antibiotics. All surgical contents were obtained from the Surgical Data System.

In the surgical approach group, we defined the case of reoperation 7 days after the first surgery as Initial treatment failure. Patients with Gram-positive and Gram-negative bacteria infections, as well as patients with multidrug-sensitive, methicillin-resistant Staphylococcus aureus (MRSA), and multidrug-resistant bacteria (MRB) infections were compared to explore the effect of types of bacterias on the outcome of septic arthritis.

At the end of the operation, drainage tubes were placed or not.

Drainage scheme: After the antibiotic solution was hung high, it was connected to the inflow tube, and the one or two outflow tubes were connected to the drainage bag, and the knee joint was irrigated through the antibiotic solution-inflow tube-knee joint-outflow tube-drainage bag pathway. The antibiotic solution is slowly injected into the knee joint by clamping the outflow tube. When the antibiotic solution is filled with the knee joint and the patient feels that the knee joint is swollen, the outflow tube is opened for drainage to form an effect similar to the distension-irrigation system. Then repeat this cycle until extubation.

The postoperative antibiotic regimen was determined by a highly qualified physician referring to the organism results, pathological results, and intraoperative findings.

The joint function evaluation is classified as follows:

(i) Complete recovery: joint swelling and pain completely disappeared, to meet the needs of daily life, for the knee joint, especially walking and up and down the stairs when there is no or almost no effect;
(ii) Basic recovery: joint swelling and fever disappeared, there was mild pain, daily life was slightly affected, for the knee joint can not walk for a long time or normal up and down the stairs;
(iii) Minor recovery: joint red, heat disappeared, leaving swelling and pain, for the knee can stand, but can not successfully complete daily life.
(iv) No recovery: joint redness, swelling, heat, pain, for the knee can not stand and walk.

For continuous variables, the Student t-test or the Mann-Whitney *U* test was used. For categorical variables, the Pearson Chi-square test or the Fisher's exact test was used for comparison between groups. The significance threshold was set to $P<0.05$. 'minor recovery' and 'no recovery' were classified as poor functional outcomes, and multivariate analysis was used to explore the risk factors of poor functional outcomes. All statistical analyses were performed using SPSS version 25.0 (IBM, NY, USA).

Results

Medical and surgical approach

Of the 125 patients, 48 were infection of artificial joints and 77 met the inclusion criteria.

The patient's baseline characteristics are shown in Table 1. The 'Other joints' in Table 1 includes shoulder, elbow, hip, sacroiliac joint and ankle. For septic arthritis, the most common joint is the knee joint (74.1% vs 92.0%, $P=0.071$).

27 patients (35.1%) in the medical approach group received only intravenous antibiotics treatment, and 50 patients (64.9%) in the surgical approach group received surgical treatment (knee arthroscopy+synovectomy).

Linezolid was the most commonly used in the two groups, followed by levofloxacin/moxifloxacin, and the third generation cephalosporin. There was no significant difference in the selection of antibiotics between the two groups ($P=0.759$).

In this study, 61/77 cases (79.2%) were positive for synovial fluid culture, of which 30/61 cases (49.2%) were Staphylococcus aureus (including 4 cases of methicillin-resistant Staphylococcus aureus), 16/61 cases of Streptococcus (4 cases of Streptococcus agalactiae, 4 cases of Streptococcus pneumoniae, 3 cases of Streptococcus pyogenes, 2 cases of Streptococcus hemolyticus, 2 cases of Streptococcus mitis, 1 case of Streptococcus dysgalactiae), and the remaining 6/61 cases of Gram-positive cocci (3 cases of Staphylococcus epidermidis, 2 cases of Staphylococcus capitis, 1 case of Staphylococcus haemolyticus). There were 8/61 cases of Gram-negative bacilli (2 cases of Escherichia coli, 2 cases of Pseudomonas aeruginosa, 1 case of Enterobacter cloacae, 1 case of Serratia marcescens, 1 case of Acinetobacter baumannii, 1 case of Proteus mirabilis), and 1 case of Candida parapsilosis. No microorganism was found in 16/77 cases (20.8%) of joint fluid culture, but white blood cells were found in knee joint fluid. There were 23/27 patients (85.2%) with positive culture in the medical approach group and 38/50 patients (76.0%) in the surgical approach group ($P=0.343$).

There were statistical differences in the changes of ESR [9.4±5.0 mm/h,18 (10.75–36.25) mm/h, $P=0.026$] and PCT [0.05 (0.00-0.09) μg/L, 0.45(0.08–0.69) μg/L, $P<0.001$] between the two groups.

At discharge, the function of 17/27 (63.0%) patients in the medical approach group was completely improved, including 15 cases of knee joint, 1 case of right ankle joint and 1 case of right shoulder joint. The pain of 33/50 (66.0%) patients in the surgical approach group disappeared and recovered completely, all of which were knee joints. There was no significant difference in the recovery between the two groups ($P=0.865$). Even after adding other joints, there was no significant difference in

Table 1 Baseline characteristics of patients in medical and surgical approach in this study

Variable	Medical approach (*n* = 27)	Surgical approach (*n* = 50)	*P*-values
Age, mean, y	59.3(4.3)	62.2 ± 1.5	*P* = 0.534
Sex, n (%)			*P* = 0.727
Male	14(51.9)	28(56.0)	
Female	13(48.1)	22(44.0)	
Jiont, n (%)			*P* = 0.071
Knee	20(74.1%)	46(92.0%)	
Others	7(25.9%)	4(8.0%)	
Comorbidities, n (%)			*P* = 0.014
≤ 2	7(25.9%)	29(58.0%)	
>2	20(74.1%)	21(42.0%)	
Hospitalization days minus antibiotic use time, d	0(0–1)	1(0–6)	*P* = 0.069
Duration of hospitalization, d	10(8–32)	17.5(9-26.25)	*P* = 0.292
Intravenous duration of antibiotics, d	10(6–32)	14(8.75–21.25)	*P* = 0.521
Combined quantity of antibiotics			*P* = 0.139
<2	15(55.6%)	19(38.0%)	
≥ 2	12(44.4%)	31(62.0%)	
Antibiotics			*P* = 0.759
Second generation cephalosporin(Cefuroxime)	8(14.8%)	17(11.2%)	
Third generation cephalosporin(Ceftizoxime, Cefoperazone, Ceftriaxone)	6(11.1%)	29(19.1%)	
Macrolides antibiotics(Vancomycin, Clindamycin)	5(9.3%)	17(11.2%)	
Oxazolidone antibiotics(Linezolid)	14(25.9%)	37(24.3%)	
Fluoroquinolone antibiotics(Levofloxacin, Moxifloxacin)	12(22.2%)	33(21.7%)	
Other antibiotics	9(16.7%)	19(12.5%)	
Organism results			*P* = 0.343
Postive	23(85.2%)	38(76.0%)	
Negtive	4(14.8%)	12(24.0%)	
WBC change value, $*10^9$/L	1.69 ± 0.7	1.95(0.58–3.85)	*P* = 0.55
CRP change value, mg/L	40.2(8.94-146.88)	37.20(9.50-83.59)	*P* = 0.557
ESR change value, mm/h	9.4 ± 5.0	18(10.75–36.25)	*P* = 0.026
PCT change value,μg/L	0.05(0.00-0.09)	0.45(0.08–0.69)	*P*<0.001

WBC: white blood cell; CRP: C-reactive protein; ESR,:erythrocyte sedimentation rate; PCT: procalcitonin

functional recovery between the two groups at discharge ($P=0.840$).

After 6 months of follow-up, 9 cases were lost to follow-up, 2 cases in the medical group (all knee joints were followed up), 7 cases in the surgical group (including 1 case of ankle joint and 6 cases of knee joints). 11/18 (61.1%) patients with medical treatment recovered completely, while 19/45 (42.2%) patients with surgical treatment recovered completely. There were 7 patients with decreased function in the medical group after 6 months of discharge, including 5 cases of Staphylococcus aureus infection, 1 case of Pseudomonas aeruginosa, and 1 case of negative culture. In the surgical group, there were 17 cases of decreased function, including 12 cases of Staphylococcus aureus infection, 1 case of Streptococcus pneumoniae, 1 case of Staphylococcus epidermidis, 1 case of Escherichia coli, 1 case of Acinetobacter baumannii, and 1 case of Pseudomonas aeruginosa. Similarly, there was no significant difference in knee function between the two groups within 6 month after discharge ($P=0.746$), and there was no significant difference in functional recovery of all joints between the two groups within 6 months after discharge ($P=0.978$). The specific functional outcome is shown in Table 2.

Multivariate analysis showed that no factors were independently associated with the patient's efficacy of joint function at discharge and 6 months after discharge ($P>0.05$). Excluding other joints, no factors were independently associated with joint function in patients with septic arthritis of knees at discharge and 6 months after discharge ($P>0.05$).

Bacteria

After excluding culture-negative cases and fungal cases, the cases with isolated Gram-positive bacteria were compared with those with isolated Gram-negative bacteria, and no difference was found between the two groups of variables (Table 3).

There was no statistically significant difference in functional outcomes between the two groups at discharge and

Table 2 Joint function outcome at discharge and 6 months after discharge according to the treatment approach, pathogens and the number of drainage tube

		Complete recovery, *n* (%)	Basic recovery, *n* (%)	Minor recovery, *n* (%)	*P*-values
The function of all joints at discharge	Medical approach (*n* = 27)	17(63.0%)	7(25.9%)	3(11.1%)	*P* = 0.840
	Surgical approach (*n* = 50)	33(66.0%)	11(22.0%)	6(12.0%)	
	Gram-positive (*n* = 52)	35(67.3%)	13(25.0%)	4(7.7%)	*P* = 0.916
	Gram-negative (*n* = 8)	5(62.5%)	3(37.5%)	0	
The function of knee joints at discharge	Medical approach (*n* = 20)	15(75.0%)	3(15.0%)	2(10.0%)	*P* = 0.865
	Surgical approach (*n* = 46)	33(71.7%)	10(21.7%)	3(6.5%)	
	Gram-positive (*n* = 48)	34(70.8%)	10(20.8%)	4(8.3%)	*P* = 0.874
	Gram-negative (*n* = 7)	5(71.4%)	2(28.6%)	0	
	0 or 2 tubes (*n* = 21)	15(71.4%)	5(23.8%)	5(4.8%)	*P* = 0.978
	3 tubes (*n* = 25)	18(72.0%)	5(20.0%)	2(8.0%)	
The function of all joints after 6 months of discharge	Medical approach (*n* = 25)	11(44.0%)	9(36.0%)	5(20.0%)	*P* = 0.978
	Surgical approach (*n* = 43)	19(44.2%)	15(34.9%)	9(20.9%)	
	Gram-positive (*n* = 47)	20(42.6%)	19(40.4%)	8(17.0%)	*P* = 0.645
	Gram-negative (*n* = 7)	2(28.6%)	4(57.1%)	1(14.3%)	
The function of knee joint 6 months after discharge	Medical approach (*n* = 20)	9(45.0%)	7(35.0%)	4(20.0%)	*P* = 0.746
	Surgical approach (*n* = 40)	19(47.5%)	15(37.5%)	6(15.0%)	
	Gram-positive (*n* = 45)	19(42.2%)	18(40.0%)	8(17.8%)	*P* = 0.776
	Gram-negative (*n* = 6)	2(33.3%)	3(50.0%)	1(16.7%)	
	0 or 2 tubes (*n* = 19)	10(52.6%)	6(31.6%)	3(15.8%)	*P* = 0.657
	3 tubes (*n* = 21)	9(42.9%)	9(42.9%)	3(14.3%)	

Table 3 Comparison of statistical data between 2 groups of patients with Gram-positive and Gram-negative pathogens

Variable	Gram-positive (*n* = 52)	Gram-negative (*n* = 8)	*P*-values
Age, mean, y	60.0(52.0-70.8)	67.0 ± 2.9	*P* = 0.110
Sex, n (%)			*P* = 0.587
Male	30(57.7)	6(75.0)	
Female	22(42.3)	2(25.0)	
Comorbidities, n (%)			*P* = 0.859
≤ 2	25(48.1%)	3(37.5%)	
>2	27(51.9%)	5(62.5%)	
Hospitalization days minus antibiotic use time, d	2.2 ± 0.5	3.8 ± 1.8	*P* = 0.310
Intravenous duration of antibiotics, d	11.8(8.0-21.8)	16.6 ± 4.1	*P* = 0.711
Combined quantity of antibiotics			*P* = 0.521
<2	23(44.2%)	2(25.0%)	
≥ 2	29(55.8%)	6(75.0%)	
Treatment approach, n (%)			*P* = 0.733
Medical approach	20(38.5%)	2(25.0%)	
Surgical approach	32(61.5%)	8(75.0%)	
Duration of hospitalization, d	13.5(8.0–29.0)	20.4 ± 3.1	*P* = 0.332

6 months after discharge (excluding patients who were lost to follow-up) (at discharge: $P=0.916$; 6 months after discharge: $P=0.645$). When only concerning the patients with septic knee arthritis, there was no statistical difference in functional outcomes between the Gram-positive bacteria group and the Gram-negative bacteria group at discharge and 6 months after discharge. See Table 2 for details.

Table 4 Initial treatment failure of patients with septic knee arthritis in the surgical group by bacteria and drug susceptibility

	Failure	*P*-values
Bacteria		*P* = 0.392
Gram-positive (*n* = 32),n(%)	10(31.3%)	
Gram-negative (*n* = 6),n(%)	3(50.0%)	
Susceptibility		*P* = 0.001
Multidrug-sensitive (*n* = 23),n(%)[a]	3(13.0%)	
Methicillin-resistant Staphylococcus aureus (*n* = 3),n(%)[b]	3(100.0%)	
Other multidrug-resistant bacteria (*n* = 12),n(%)[b]	7(58.3%)	

Compared with [a] and [b], $P<0.017$

In patients diagnosed with with septic knee arthritis in the surgical group, Gram-positive bacteria were compared with Gram-negative bacteria, and patients with Gram-negative related infections showed a greater initial surgical failure rate (50.0% vs. 31.3%, $P=0.392$). However, the difference was not significant (Table 4).

In the cases of initial surgical failure, the treatment failure rate was 13.0% in the multidrug-sensitive bacteria group, 100% in the methicillin-resistant Staphylococcus aureus group, and 58.3% in the other multidrug-resistant bacteria group ($P=0.001$) (Table 4).

Table 5 Baseline characteristics of patients in 0 or 2 drainage tubes group and 3 drainage tubes group

Variable	0 or 2 drainage tubes (*n* = 21)	3 drainage tubes (*n* = 25)	*P*-values
Age, mean, y	62.7(2.6)	62.4 ± 2.0	*P* = 0.914
Sex, n (%)			*P* = 0.806
Male	11(52.4)	14(56.0)	
Female	10(47.6)	11(44.0)	
Comorbidities, n (%)			*P* = 0.895
≤ 2	8(38.1%)	15(60.0%)	
>2	13(61.9%)	10(40.0%)	
Hospitalization days minus antibiotic use time, d	0(0-8.5)	1(0-4.5)	*P* = 0.963
Symptom duration between hospital and surgical treatment, d	7.0(1.1)	6.6(0.7)	*P* = 0.757
Duration of hospitalization, d	19.1(2.5)	17.6(1.8)	*P* = 0.639
Intravenous duration of antibiotics, d	11(8–20)	14(9–23)	*P* = 0.650
Combined quantity of antibiotics			*P* = 0.923
<2	14(66.7%)	17(68.0%)	
≥ 2	7(33.3%)	8(32.0%)	
Antibiotics			*P* = 0.999
Second generation cephalosporin(Cefuroxime)	8(11.6%)	9(11.1%)	
Third generation cephalosporin(Ceftizoxime, Cefoperazone, Ceftriaxone)	13(18.8%)	16(19.8%)	
Macrolides antibiotics(Vancomycin, Clindamycin)	8(11.6%)	9(11.1%)	
Oxazolidone antibiotics(Linezolid)	17(24.6%)	20(24.7%)	
Fluoroquinolone antibiotics(Levofloxacin, Moxifloxacin)	15(21.7%)	16(19.8%)	
Other antibiotics	8(11.6%)	11(13.6%)	
Organism results			*P* = 0.905
Postive	18(85.7%)	20(80.0%)	
Negtive	3(14.3%)	5(20.0%)	
WBC change value, $*10^9$/L	2.1(0.4–4.1)	1.9(0.6–4.9)	*P* = 0.947
CRP change value, mg/L	49.8(11.0)	52.8(11.6)	*P* = 0.857
ESR change value, mm/h	16.9(6.1)	21.0(3.2)	*P* = 0.532
PCT change value,μg/L	0.24(0.07–0.63)	0.47(0.23–0.74)	*P* = 0.139

WBC: white blood cell; CRP: C-reactive protein; ESR,:erythrocyte sedimentation rate; PCT: procalcitonin

Drainage tubes

For patients undergoing knee arthroscopic surgery, there were 7 patients without drainage tube, 14 patients with 2 drainage tubes, and 25 patients with 3 drainage tubes.

According to the number of drainage tubes, patients undergoing knee arthroscopic surgery were divided into two groups: patients with 0 or 2 drainage tubes and patients with 3 drainage tubes. The patients' baseline characteristics are shown in Table 5. There was also no statistically significant difference in functional outcomes between the two groups at discharge and 6 months after discharge (excluding patients who were lost to follow-up) (discharge: P = 0.978; 6 months after discharge: P = 0.657). See Table 2 for details.

51/66 elderly patients with septic arthritis of knee joints were combined with knee osteoarthritis. 19/51 patients were unable to determine whether the imaging findings were caused by infection due to the lack of imaging data before the onset of the disease. 15/51 patients showed osteoarthritis symptoms such as pain before the onset of the joint infection and had subsequent recommendations for arthroplasty in the informed consent form. The ultimate results of such patients can be predicted at admission.

In the medical approach group, 1 patient underwent unicompartmental knee arthroplasty, 1 patient underwent total knee arthroplasty, and 1 patient was considered for total knee arthroplasty. In the surgical group, patients with septic arthritis of hip joints were treated with total hip replacement. Among the patients with septic arthritis of knee joints, 1 patient had undergone total knee arthroplasty, and 3 patients were considered for unicompartmental or total knee arthroplasty.

Discussion

In this study, we observed that there was no statistically difference in the functional improvement of septic arthritis of natural joints between medical and surgical approach. This conclusion is consistent with previous retrospective studies [5–7]. Kaoru et al. proved that there was no significant difference in the long-term functional effects of medical and surgical treatment on septic arthritis, up to 12 months after discharge [7]. Multivariate analysis showed that no factors were independently

associated with the patient's efficacy of joint function at discharge and 6 months after discharge.

Regarding the type of microorganism causing the infection, Gram-positive cocci are the main pathogens of septic arthritis, the most common of which is Staphylococcus aureus, followed by Streptococcus. Our results are similar to previous studies [8–10]. But Gram-negative cocci, atypical bacterial and fungal infections can not be ignored [11].

Gram-positive bacteria and Gram-negative bacteria do not seem to affect the length of hospital stay and short-term functional outcomes of patients, and for patients undergoing surgical approach, the type of bacteria does not seem to affect the rate of surgical failure. A study involving different etiologies of septic arthritis showed that there does not seem to be any significant difference between Gram-positive and Gram-negative infections [12]. However, when it comes to drug resistance, as shown in our study, we observed that for patients with septic knee arthritis, the initial surgical failure rate of the multidrug-sensitive bacteria group was 13.0% (3/23), the methicillin-resistant Staphylococcus aureus group was 100% (3/3), and other multidrug-resistant bacteria group was 58.3% (7/12), and the initial surgical failure rate of patients with MRSA and other multidrug-resistant bacteria infection was statistically different from that of multidrug-sensitive bacteria infection.

Bruno et al. suggested that the drug resistance affects the outcome of surgery [13], especially for multidrug-resistant Gram-negative bacteria. The infection recurrence rate and surgical failure rate are even greater than MRSA. This means that the type of bacteria (multidrug-resistant bacteria or more aggressive) in people with septic knee arthritis may play a role in treatment decisions. However, some authors did not find significant differences in the results when comparing multidrug-sensitive bacteria and multidrug-resistant bacteria [5].

Although 16/77 specimens were negative for culture, infection could not be ruled out [4], and antibiotic therapy or surgical treatment was effective in these 16 cases of highly suspected infection. For patients with suspected septic arthritis but negative culture, the specific types, usage and time of antibiotics should be adjusted according to clinical manifestations and regional epidemiology [14].

Septic arthritis should be treated with antibiotics immediately after obtaining blood and synovial fluid samples. Due to the lack of high-quality evidence, no antibiotic regimen has shown optimal efficacy. In principle, the initial antibiotic regimen is recommended to best cover Gram-negative, Gram-positive and methicillin-resistant Staphylococcus aureus (MRSA) and other possible multiple resistant bacteria [15, 16], but this undoubtedly increases the concerns generated by multiple resistant bacterias.

A recent meta-analysis of 11 randomized controlled trials involving 1,063 patients showed that linezolid seems to be the most promising treatment for Staphylococcus-associated bone and joint infections [17]. It also showed acceptable long-term adverse reactions [18]. However, this undoubtedly increases the likelihood of the emergence of linezolid-resistant multidrug-resistant Staphylococcus epidermidis (LR-MDRSE) strains, which is concerning. However, due to the limited evidence, the results of the study need to be confirmed by further high-quality randomized controlled trials.

Fluoroquinolones are a class of broad-spectrum antimicrobial agents that are active against a variety of aerobic Gram-positive and Gram-negative bacteria. The most widely used are ciprofloxacin, levofloxacin and Fluoroquinolones, which are effective for septic arthritis [19, 20], but the specific efficacy depends on drug exposure and the level of resistance of the bacteria causing the infection [21, 22].

Cefuroxime [23] and cefazolin [24] have been proved to be effective septic arthritis of large joints, but they cannot cover many pathogenic bacteria and may be suitable for hospitals with specific epidemiology.

Third-generation beta-lactam antibiotics are effective against a wider range of microorganisms, which are safe and effective as the only therapeutic agent for many orthopedic infections (including infections requiring long-term treatment) [25].

Ceftizoxime has broad-spectrum in vitro activity against Gram-positive and Gram-negative bacteria, but its activity against Staphylococcus is not as good as that of early cephalosporins, so it is generally not used as the preferred drug for septic arthritis. Ceftizoxime appears to be an effective supplement to an increasing number of third-generation cephalosporins [26].

Ceftriaxone is generally used for Gram-negative cocci. It is the preferred antibiotic for patients with bone and joint infection caused by Enterobacteriaceae (except Pseudomonas aeruginosa and ESBL-producing bacteria). It is also an effective treatment option for Streptococcus, MSSA or Propionibacterium acnes. Guillaume et al. suggested that ceftriaxone may be the preferred antibiotic for the treatment of undocumented bone and joint infections. It may be more beneficial when combined with aminoglycoside antibiotics [27].

Cefoperazone/sulbactam is a β-lactam and β-lactamase inhibitor combination therapy for the treatment of severe infections. Including many multi-antibiotic resistant strains. It may have a better effect on Acinetobacter baumannii [28].

For methicillin-resistant Staphylococcus aureus (MRSA) infection, daptomycin, Linezolid, quinupristin/

dalfopristin, minocycline or vancomycin are all effective. Due to side effects (increased minimum inhibitory concentration) and increased prevalence of Vancomycin-Resistant Enterococcus (VRE), the use of vancomycin is less [29]. There is no difference in virulence between MSSA and MRSA infections if treatment is initiated early and effective antibiotics are used in vivo.

It should be noted that although Gram-positive cocci are still the main pathogens of septic arthritis, some studies have suggested that the types of pathogens have changed significantly in recent years. Clinical isolates of Gram-negative bacilli increased significantly. And the resistance of several major Gram-negative bacilli to piperacillin/tazobactam, cefoperazone/sulbactam, meropenem and imipenem is on the rise [30]. For people with septic arthritis, maybe the clinical treatment is not the standard care, and the type of bacteria (multidrug-resistant bacteria or more aggressive) should be taken into account when determining the specific treatment.

According to the curative effect, multiple culture results and even intraoperative findings, it is a wise choice to reasonably combine antibiotics and change or upgrade antibiotics if necessary. In this study, whether it is the medical or the surgical group, the performance of linezolid is undoubtedly excellent.

Surgical benefits

Although there seems to be no statistically significant difference between medical treatment and arthroscopic treatment in this study, surgical treatment also has its advantages.

Previous literature suggested that arthroscopic treatment of shoulder and hip joint would have better curative effect [6]. But for the knee, there seems to be no optimal treatment.

Supporters of the surgical approach value its ability to completely clean the joints, remove necrotic synovium, reduce the damage to articular cartilage, and make functional recovery more thorough, and through a thorough assessment of the joints to predict the prognosis and guide follow-up treatment. Laurent et al. believed that arthroscopic debridement should be a routine treatment. When there is obvious synovial hypertrophy (Gächter stage III and IV) or more conservative treatment cannot be quickly improved, synovectomy should be considered as the main surgery [10]. So maybe the medical treatment might not always be adequate for every patient.

In this study, 71.4% of the patients finally underwent surgical treatment, with the following possible reasons: 1. Hospitalization department will affect the choice of treatment options, such as rheumatology, pain and other departments tend to medical treatment, orthopedics has the opportunity to surgical treatment; 2. Arthroscopic surgery is helpful to evaluate the joint condition of some elderly patients with severe osteoarthritis in order to provide recommendations for subsequent arthroplasty; 3. Some doctors who have a greater grasp of arthroscopy tend to perform surgical treatment.

Drainage tubes

Placing the drainage tube and irrigating the joint have been shown to be effective in previous studies [31, 32].

The drainage can be achieved by serial closed needle aspiration at the bedside or surgically (arthrotomy or arthroscopy). Studies have shown that there is no statistical difference in complications between medical and surgical drainage [33, 34].

Although needle aspiration and arthroscopic surgery are invasive operations and have the risk of further infection, previous literature results suggest that the risk of recurrence after medical and surgical treatment is similar [7]. The impact of pathogens on the clinical course of the disease is greater than the treatment chosen [15, 35].

However, in previous literature, placing the drainage tube and irrigating the joint after arthroscopic surgery has a more positive impact, including reducing antibiotic use time and hospital stay [32], and provides better results in eradicating infection and improving joint function than repeated needle aspiration or arthrotomy [36].

However, the number of drainage tubes and the way of irrigation after arthroscopic surgery are controversial. Conventional placing drainage tubes and irrigation, such as the continuous irrigation-suction drainage system based on Willenegger's research results [37], and distension-irrigation system based on Jackson & Parsons [38], etc., but in any case, the inflow tube is generally in the suprapatellar region, and the outflow tube is in the anterior inferolateral approach or anteromedial of the knee joint [32]. The draining time is generally based on the color of the outflow fluid [32], generally 6 ~ 8 days, or based on the negative results of multiple cultures of the drainage fluid. The time of intravenous antibiotics is generally based on the patient's clinical manifestations and laboratory indicators, followed by oral antibiotics for at least 6 weeks.

The two outflow tubes are relatively rare in the previous literature. The two outflow tubes were placed in the anteromedial and lateral sides, respectively, and the inflow tube could be placed in the suprapatellar recess [39].

In this study, there was no significant statistical difference in the outcome between the two groups of 0 or two drainage tubes and 3 drainage tubes. In spite of this, the author still supports 3 drainage tubes. First of all, not all hospitals are equipped with a flushing-suction system, and the drainage methods in this study can be completed in most hospitals; in addition, if one outflow tube is blocked, the other outflow tube can still play a drainage

role; otherwise, the two outflow tubes can fully drain the medial tibiofemoral and lateral tibiofemoral, which seems to be able to play a better role in drainage.

Arthroplasty

In addition, it is necessary to inform eligible patients of the possibility and risk of subsequent arthroplasty, especially those with severe osteoarthritis before infection. For patients undergoing arthroscopic surgery before, in a study involving 12 132 patients, 152 patients underwent arthroplasty during a follow-up of at least 1 year. Within 15 years, the annual risk of arthroplasty was about 6 times that of the general population [40].

Although previous arthroscopy does not affect the function after primary arthroplasty [41, 42], it is controversial about the survival rate and complications after arthroplasty including infection, prosthesis loosening and periprosthetic fractures [43–45].

However, it is undeniable that arthroplasty after septic arthritis requires a long process. Brian C Werner's study shows that complications do not increase when the Total Knee Arthroplasty is performed more than 6 months after knee arthroscopy [46].

In the follow-up, 1 patient in the medical group underwent unicompartmental knee arthroplasty (9 months after discharge), 1 patient underwent total knee arthroplasty (13 months after discharge), and the other 1 patient was considering for total knee arthroplasty. 1 patient in the surgical group had undergone total knee arthroplasty (17 months after discharge), and 3 patients were considering for unicompartmental or total knee arthroplasty. All patients undergoing surgery had good function. The proportion of patients who finally chose or tended to choose arthroplasty in the medical group seemed to be higher (3/20 cases, 15.0% VS 4/46 cases, 8.7%). Prospective studies with longer follow-up time are needed to prove the above conclusions.

However, for septic arthritis of hip joints, the functional outcomes at discharge in this study seem to be unsatisfactory. As an important joint in daily activities, arthroplasty seems to be a good choice for patients over 65 years old. Through telephone follow-up we learned that 3 patients with septic arthritis of hip joints were considering for arthroplasty in the later stage.

Limitation

There are some limitations in our research. First of all, due to the low incidence of septic arthritis, we cannot obtain the expected ideal sample size of the experimental group and the control group. The number of cases in the medical group is less than that in the surgical group, which undoubtedly affects the statistical power of the difference between the groups and the power of the study. In addition, our study was retrospective, and due to the different departments of internal medicine and surgery chosen by patients on admission, this led to selection bias. The choice of antibiotics is also related to the patient's condition and the doctor's experience, which seems unexplained.

Our outcome variables are based on the subjective criteria of patients' clinical symptoms and daily activities. This is related to the department where the patient is hospitalized. Different departments cannot provide the same scoring scale. We can only obtain clinical symptoms and daily activities from medical records and nursing records, and verify them by telephone.

At the same time, multivariate analysis did not show independent risk factors associated with functional prognosis, which may be related to the sample size and other related factors not included in this study. More studies with better methodology should be done to prove the above results in the future. In addition, future studies need to further increase the follow-up time. In recent years, few studies have compared these two methods. We have supplemented the research septic arthritis in native joints in South China, and proposed a simple and effective drainage device suitable for primary hospitals.

Conclusion

According to our study, the efficacy of medical approach and surgical approach for septic arthritis in functional recovery seems to be similar. The medical treatment is not the standard care, which might not be adequate for every patient, and arthroscopic treatment can still be actively used when necessary. Maybe the type of bacteria (gram negative or more aggressive ones) can play a role in the choice of treatment strategy. In addition, the number of drainage tubes after arthroscopic surgeries does not seem to affect the patient's knee function. There is a risk of subsequent arthroplasty in patients with septic arthritis with severe osteoarthritis. Further more studies with better methodology should be done to confirm the results found.

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Author contributions

Qiyuan Lu: Conceptualization, Methodology, Software, Investigation, Formal Analysis, Writing- Original Draft; Xiaoqiang Yang: Data Curation, Software, Validation; Mengmeng Chen: Visualization, Investigation; Zhiqiang Mao: Resources, Supervision; Houfu Ling: Visualization, Writing - Review & Editing.

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Data availability

Data cannot be provided due to identifying information of participants but is available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Approval was received by the Ethics Committee of the first hospital of Zhejiang Chinese Medical University and obtained the unique identification number of research registration (2023-YS-004-02). Written informed consent for participation was obtained from all participants. All procedures were performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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