Conservative management of hemodialysis catheter-related infections feasibility and clinical outcomes

Samia Zitouni[a], Isma Temacini[a], Messaoud Saidani[b]

[a]Department of Nephrology, Dialysis and Kidney Transplantation, Specialized Hospital for Organ and Tissue Transplantation, Blida, Algeria, [b]Department of Nephrology, Dialysis and Kidney Transplantation, Beni Messous Hospital, Algiers, Algeria

Correspondence to Samia Zitouni, Assistant Professor of Nephrology, Department of Nephrology, Dialysis and Kidney Transplantation, Specialized Hospital for Organ and Tissue Transplantation, 09000, Blida, Algeria
Tel: 213772640677
E-mail: samiazitouniamel@gmail.com

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Background
Catheter-related infections in hemodialysis remain a major problem. Management strategies vary widely between catheter removal and conservative management. This study evaluates the feasibility and outcomes of a conservative catheter-preservation approach.

Methods
This retrospective study, conducted over 20 months at Beni Messous University Hospital (Algiers), analyzed the management of 69 catheter-related infections occurring in patients undergoing hemodialysis via nontunneled central venous catheters. A local protocol was implemented consisting of conservative management for jugular catheter infections, while femoral catheters were systematically removed except in cases where no alternative vascular access was available. Conservative treatment was avoided in patients with hemodynamic instability, persistent fever beyond 72 h, or metastatic complications.

Results
During the study, 365 central venous catheters were placed in 250 patients, with 69 developing infections. Patients were mainly young adults (mean age 50.6 years) with slight male predominance (50.7%) and frequent comorbidities such as diabetes or hypertension. Jugular access was used in 52.2% of cases, while nearly half required femoral insertion; over 72% remained in place more than 10 days. Among infected catheters, 53 (76.8%) were removed, including 24 jugular lines, while 16 (23.2%) were successfully preserved with complete resolution. Coagulase-negative staphylococci were most common (30.1%), followed by *Staphylococcus aureus* (18.8%). Systemic signs (fever, chills, C-reactive protein elevation, leukocytosis) were the only significant predictor of removal ($P = 0.035$).

Conclusion
A risk-based strategy, preserving jugular catheters with local signs and removing high-risk cases, suggests catheter salvage may be a safe alternative to routine removal.

Keywords:
antibiotic, catheter-related infection, conservative, hemodialysis

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Introduction

Non-tunneled central venous catheters (CVCs) for hemodialysis are frequently used as vascular access for patients requiring emergency hemodialysis sessions, but infectious complications remain a major clinical problem. Catheter-related bloodstream infections (CRBSIs) have a negative impact on survival, hospitalization, mortality, and overall healthcare costs in this setting.

Infections associated with hemodialysis catheters are classified as local catheter-related infection without bacteremia (colonization with signs of local infection) and CRBSI [1–3].

The KDOQI defines CRBSI as the combination of clinical manifestations and at least one positive blood culture from a peripheral source (dialysis circuit or vein) and no other apparent source, with a positive semiquantitative culture (>15 CFU/catheter segment, tip, or end) or quantitative culture (>10^2 CFU/catheter segment; tip, or end), in which the same organism (species and antibiogram) is isolated from the catheter segment (tip or end) and a blood sample from a peripheral source (dialysis circuit or vein). If available, the following would be useful: simultaneous quantitative cultures of blood samples with a ratio of more than oo equal to 3: 1 [catheter segment vs. peripheral (dialysis circuit/vein)]; differential period of 2 h between catheter culture and peripheral culture positivity [4].

Clinically, fever is found in ~50% of patients with CRBSI, and isolated chills are described in ~30% of cases. Other local and general clinical signs are possible: malaise, fainting, or hypotension [5].

The probability of fever depends on the pathogen: 77% of cases of *Staphylococcus aureus* bacteremia, 46% in cases of Gram-negative bacteria, 33% in cases of *Staphylococcus epidermidis*, and 23% in cases of enterococcus [6].

There are four mechanisms of CVC contamination. The most common is the migration of cutaneous microorganisms at the catheter insertion site. The external segment can be infected directly as a result of handling the catheter with contaminated hands, equipment, or fluids. Alternatively, the infection may originate from a distant infectious site via the bloodstream [7].

Biofilm formation is a major factor in the pathophysiology of CVC infections. It is a matrix of extracellular polysaccharides formed on the surface of the catheter by the adhesion of planktonic organisms [8]. It is present on the internal and external surfaces of the catheter and forms within 24 h after placement [9].

According to published studies, the frequency of catheter related infection varies from 1.0 to 5.5 episodes per 1000 catheter days [10–12]. To date, the only Algerian study addressing CVC-related infections in hemodialysis was a prospective investigation conducted on nontunneled hemodialysis catheters, reporting an incidence rate of 16.6 episodes per 1000 catheter days. Of these infections, 12 were catheter-related infection without bacteremia (7.8%, 5.8 per 1000 KT-days) and 22 were CBSRIs (14.6%, 10.8 per 1000 KT-days), highlighting the scale of the problem in our local context [13].

Compared to patients with arteriovenous fistula, those hemodialyzed with catheters have a two to three times higher risk of hospitalization due to infections [14]. Catheter-related infections result in significant morbidity and a mortality rate that is more than 50% higher than in patients with native arteriovenous fistulas [15]. In addition, metastatic infections are present in 5–10% of patients with catheter-related sepsis, in the form of osteomyelitis, endocarditis, septic arthritis, and epidural abscess [16].

Replacing the catheter (i.e. removing it and placing it in a new location) at regular intervals as a measure to reduce catheter-related infections has not been shown to decrease infection rates [7]. It has also been shown by Uldall *et al.* [17] that there is no difference in rates between patients who undergo scheduled catheter replacement every 7 days and patients whose catheters are replaced as needed.

Scheduled replacement of guidewire-guided CVCs is another strategy proposed to prevent catheter-related infections. A literature review of 12 randomized controlled trials evaluating CVC management did not demonstrate a reduction in infection rates compared to replacement of the catheter as needed [18].

For catheters that are already infected, several management strategies have been discussed, ranging from treatment with the device in place to its removal in order to optimize management. Replacing temporary catheters on a guidewire in the presence of bacteremia is not always an acceptable strategy, as the source of infection is usually colonization of the cutaneous pathway between the insertion site and the vein [19]. Furthermore, several data in the literature suggest that the risk of infection is higher when using a second catheter compared to the first [20], reinforcing the need to preserve the initial device as long as possible.

Regarding the management of CBSRIs, the 2019 KDOQI guidelines have defined four main options involving the removal or retention of the CVC, as follows:

(1) Removal of the CVC:
(2) Removal of the CVC with its replacement with a guidewire at the same site.
   (a) Removal of the CVC with its replacement at a new site [±duration "without CVC" (period during which the patient does not have a CVC *in situ*)]. Several situations require this last option, namely immediate removal of the CVC and delayed placement of the new CVC.
   (b) Clinically and hemodynamically unstable patients.
   (c) Persistent fever 48–72 h after initiation of systemic antibiotic therapy.
   (d) Persistent bacteremia 48–72 h after initiation of antibiotic therapy.
   (e) Metastatic complications, including suppurative thrombophlebitis, endocarditis.
   (f) Infections caused by *S. aureus*, *Pseudomonas aeruginosa*, fungi, or mycobacteria.
   (g) Presence of infection at the tunnel site.

CVC conservation:

(1) Maintain the CVC and use the antibiotic CVC lock.
(2) Maintain the CVC without using the antibiotic CVC lock.

In this context, the strategy adopted in our center is to retain the catheter in cases of infection unless clear indications for removal exist, favoring appropriate antibiotic therapy with the device in place. This approach was undertaken after synthesizing current guidelines and published evidence, while also taking into account our local microbial ecology and economic constraints.

The objective of this study is therefore to evaluate the efficacy and safety of our approach.

Materials and methods

This retrospective study was conducted in the Dialysis Emergency Unit of the Nephrology Department at the Beni Messous University Hospital Center (Algiers), a referral facility providing care for all dialysis emergencies in the western region of Algiers.

Over a 20-month period, from February 2021 to September 2022, 356 patients with severe renal failure underwent hemodialysis sessions. These patients, who did not have permanent vascular access, required the insertion of a nontunneled CVC. Among these catheters, 69 developed catheter-related infections.

This study did not distinguish between local catheter-related infections without bacteremia and CRBSI, due to logistical constraints related to the supply of blood culture bottles. The diagnosis of CVC-related infection was established in the presence of local or systemic clinical signs of CVC-related infection and in the absence of other infection sites.

All CVCs were inserted by nephrologists. Antisepsis of the insertion site and the extended field was performed using povidone-iodine. The insertion sites, in order of preference, were the internal jugular vein followed by the femoral vein, except for patients presenting with respiratory distress.

To avoid potential subclavian vein stenosis, this site was not used. All catheters were intended for short-term use, sutured to the skin, and covered with a dressing consisting of sterile gauze and adhesive tape.

The catheters were used exclusively for hemodialysis. At the end of each hemodialysis session, the catheters were flushed with sodium heparin solution, without the use of antimicrobial lock solutions. No antiseptic dressings were used. Dressing changes were performed aseptically before each session, three times per week. A nurse inspected the insertion site for signs of infection during each dressing change. In cases of suspected infection, the nephrologist was immediately notified.

Prior to this study, a preliminary analysis of the microbial ecology of the center was conducted to guide the selection of empirical antibiotic therapy. This investigation revealed that the most frequently isolated pathogen was coagulase-negative staphylococci (CoNS), susceptible to first-generation cephalosporins (cephalexin).

These data enabled us to adopt an internal policy comprising:

Systematic removal of all infected femoral catheters, except in the following specific situations: patients with no alternative vascular access or belonging to specific populations, particularly those with psychiatric disorders at risk of device self-removal.

Conservative management of all infected jugular catheters, except when: (a) patients are clinically and hemodynamically unstable, (b) fever persists 48–72 h after initiation of systemic antibiotic therapy, (c) bacteremia persists 48–72 h after starting antibiotic therapy, (d) metastatic complications occur, including suppurative thrombophlebitis or endocarditis.

This approach is in accordance with the 2019 KDOQI guidelines.

In cases of *S. aureus* and *P. aeruginosa* infections, and contrary to the 2019 KDOQI guidelines which recommend catheter removal in these situations, we opted to retain the device. This decision was based on the consideration that antibiotic susceptibility patterns may vary according to country and local context [21,22], as well as the results of our preliminary study.

However, we systematically removed CVCs when the infection was caused by *Acinetobacter baumannii*.

From patient dialysis records, we collected information regarding: age, sex, comorbidities (diabetes, hypertension, immunosuppression, etc.), local clinical signs (erythema at the catheter exit site, pain with or without purulent discharge), systemic clinical signs (fever, chills, sweating), and biological markers (elevated C-reactive protein, leukocytosis).

The presence of systemic clinical signs (fever, chills) or biological markers (elevated C-reactive protein and/or leukocytosis), in the absence of another infectious source, was considered suggestive of catheter-related bacteremia.

In patients already receiving antibiotic therapy for a concurrent infection, a catheter-related infection was only considered when it occurred after complete clinical and biological resolution of the initial infection and at the end of the antibiotic course. In this situation, CVC removal was systematically performed.

Other situations prompted CVC removal: maturation of a previously created arteriovenous fistula in chronic kidney disease patients, immunocompromised status, catheter dysfunction, or an extensively prolonged catheterization (>30 days).

The date of CVC insertion, insertion site, and duration of catheterization were also recorded.

For each catheter retained, a specimen was collected from the insertion site using a sterile swab in the presence of pus or local secretions, along with an intraluminal blood sample when feasible. These samples were immediately sent to the microbiology laboratory for culture.

For removed catheters, the implanted portion, from the skin interface to the distal tip, was transported in a sterile container and cultured using standard techniques (semiquantitative culture).

It should be noted that peripheral or paired blood cultures, considered the gold standard for diagnosing catheter-related infections, were not performed in our study due to inconsistent availability of blood culture bottles.

Upon suspicion of CVC-associated infection, empirical antibiotic therapy with cephalexin was initiated, then adjusted according to antimicrobial susceptibility testing results.

Statistical analyses were performed using IBM SPSS Statistics, version 26.0 (IBM Corp., Armonk, New York, USA).

Table 1 Characteristics of the study population and central venous catheters

Characteristics	Total (*N*=69)
Age in years (mean±SD)	50.64±19.13
Age groups	*n* (%)
>60 years	22 (31.9)
<60 years	47 (68.1)
Sex	*n* (%)
Male	35 (50.7)
Female	34 (49.3)
Comorbidities	*n* (%)
HTN	14 (20.3)
Diabetes II+CKD	13 (18.8)
IS	11 (15.9)
Diabetes II+HTN+CKD	5 (7.3)
HTN + diabetes II+IS	5 (7.3)
Diabetes II+IS	1 (1.4)
None	20 (29.0)
Hygiene status	*n* (%)
Good	41 (59.4)
Moderate	3 (4.3)
Poor	25 (36.2)
CVC site	*n* (%)
Jugular vein	36 (52.2)
Femoral vein	33 (47.8)
Catheterization duration	*n* (%)
<10 days	19 (27.5)
>10 days	50 (72.5)
Catheterization duration for each site	*n* (%)
Jugular vein (<10 days) (>10 days)	9 (13.1), 27 (39.2)
Femoral vein (<10 days) (>10 days)	10 (14.4) 23 (33.3)
Clinical signs	*n* (%)
Local	36 (52.2)
Systemic	33 (47.8)
CVC removal	*n* (%)
Yes	53 (76.8)
No	16 (23.2)

CKD, chronic kidney disease; CVC, central venous catheters; HTN, hypertension; IS, immunosuppression.

Results

During the study period, 365 CVCs were placed in 250 patients. 69 CVCs developed catheter-associated infections.

The characteristics of patients and CVCs are summarized in Table 1.

Our study population consisted of two-thirds young adults, with a mean age of 50.64 ± 19.13 years. A slight male predominance was observed. The majority of patients had diabetes and/or hypertension. Immunosuppressive therapy was administered in 17.4% of patients. More than half of the CVCs remained in place for longer than 10 days. The internal jugular vein was the most frequently used site (52.2%), although the femoral vein was accessed in nearly 50% of cases due to ease of insertion in emergency situations.

Poor personal hygiene was noted in 36.2% of patients.

Of the 69 infected CVCs, 37 (53%) were removed during the study period. Among removed catheters, 24 (66.7%) were jugular catheters (Table 2).

Treatment failure with appropriate antibiotic therapy accounted for only two removals of jugular catheters. Importantly, all patients experienced complete resolution of infection with the conservative approach.

The primary indications for removal were: arteriovenous fistula maturation in six chronic kidney disease patients (allowing transition from catheter to fistula access) and prolonged catheterization exceeding 30 days. Complete removal indications are detailed in Table 3.

The remaining 32 infected CVCs (47%) were managed conservatively with systemic antibiotics.

Seven (10.1%) patients had culture-negative catheter-associated infections. In these cases, diagnosis was established based on clinical criteria consistent with published guidelines [23]: presence of systemic manifestations (fever, acute inflammatory response, organ dysfunction) or local insertion site signs (erythema, purulent drainage, cellulitis) without an identified alternative infectious source, despite negative blood, and catheter cultures. The complete microbiological profile is presented in Table 4.

Risk factors associated with infected catheter removal were analyzed by comparing patients who underwent catheter removal with those managed conservatively. Findings are presented in Table 5.

Systemic manifestations, defined as fever, chills, elevated C-reactive protein, and/or leukocytosis, represented the only significant predictor of catheter removal ($P = 0.03$).

Spearman's rank correlation analysis demonstrated a weak but statistically significant positive correlation between catheter removal and systemic clinical-laboratory findings ($\rho=0.251$; $P = 0.037$; $N = 69$), indicating that patients with systemic manifestations had a higher likelihood of requiring catheter removal.

Table 2 Central venous catheters removal rate

	Yes	No
Jugular CVC, *n* (%)	24 (66.7)	12 (33.3)
Femoral CVC, *n* (%)	29 (87.9)	4 (12.1)

CVC, central venous catheter.

Table 3 Reason for removal of jugular catheter

Reason for removal of jugular catheter	*n* (%)
No response to appropriate antibiotic therapy	2 (8.3)
Recovery of renal function	1 (4.2)
Infection under antibiotic therapy	3 (12.5)
Immunocompromised patient	4 (16.7)
Duration	5 (20.8)
Arteriovenous fistula maturation	6 (25.0)
Acinetobacter isolated in blood culture	1 (4.2)
Severe sepsis	1 (4.2)
CVC dysfunction	1 (4.2)

CVC, central venous catheter. Coagulase-negative staphylococci (CoNS) were the most frequently isolated pathogens, representing one-third of infections, followed by *Staphylococcus aureus* (18.8%).

Table 4 Microorganisms identified during infections

Microorganism	*n* (%)
Staphylococcus aureus	13 (18.8)
Sterile	7 (10.1)
Not received at laboratory	11 (15.9)
Coagulase-negative *Staphylococcus*	21 (30.1)
Pseudomonas aeruginosa	8 (11.6)
Klebsiella pneumoniae	2 (2.9)
Enterococcus sp	3 (4.3)
Enterobacter	1 (1.4)
Proteus vulgaris	1 (1.4)

Discussion

This retrospective study evaluated the feasibility of catheter-sparing management for CVC-associated infections in hemodialysis patients. Among 69 infected nontunneled CVCs identified over a 20-month period, our conservative approach achieved 100% clinical resolution with zero mortality by completion of antibiotic therapy and no relapse or recurrence was observed during a 3-month follow-up period. Notably, 46.4% (32/69) of infected catheters were successfully managed without device removal, challenging the conventional practice of routine catheter extraction for all CVC-associated infections.

Our analysis identified the presence of systemic manifestations, defined as fever, chills, elevated C-reactive protein, and/or leukocytosis, as the only significant predictor of catheter removal ($P = 0.035$). Importantly, other variables including age, sex, catheterization duration, hygiene status, and isolated pathogen did not significantly influence management decisions or outcomes in our cohort.

Several factors likely contributed to the successful conservative management observed in our study:

Selective catheter removal strategy: we implemented a risk-stratified approach wherein catheters were systematically removed in high-risk scenarios: femoral site infections, immunocompromised patients, infections occurring during antibiotic therapy for prior infections, isolation of multidrug-resistant *A. baumannii*, and severe sepsis. This selective removal strategy allowed retention of jugular catheters in clinically stable patients with favorable microbiology, while promptly removing catheters in situations associated with poor outcomes.

Optimized empirical therapy: preliminary microbiological surveillance of our unit revealed CoNS as the predominant pathogen, with preserved susceptibility to first-generation cephalosporins. This informed our empirical regimen of cephalexin, which provided appropriate coverage for the majority of infections while antibiotic susceptibility results were pending. Subsequent tailoring of therapy based on culture results and clinical response optimized treatment efficacy.

Patient demographics: our population was relatively young (mean age 50.64 ± 19.13 years) compared to typical

Table 5 Correlation analysis of factors associated with catheter removal

Variable 1	Variable 2	Spearman's ρ	*P* (two-tailed)	*n*
Catheter removal	Clinical-biological signs	0.251	0.037	69

Variable	Removal: yes (*n*=53)	Removal: no (*n*=16)	*P*
Age			
<60 years	34 (72.3)	13 (27.7)	
>60 years	19 (86.4)	3 (13.6)	0.198
Sex			
Male	27 (77.1)	8 (22.9)	
Female	26 (76.5)	8 (23.5)	0.947
Hygiene status			
Good	32 (78.0)	9 (22.0)	
Moderate	2 (66.7)	1 (33.3)	
Poor	19 (76.0)	6 (24.0)	0.897
Comorbidities			
HTN	10 (71.4)	4 (28.6)	
Diabetes II+CKD	8 (61.5)	5 (38.5)	
IS	10 (90.9)	1 (9.1)	
Diabetes II+HTN+CKD	3 (60.0)	2 (40.0)	
Diabetes II+HTN+IS	4 (80.0)	1 (20.0)	
Diabetes II+IS	1 (100.0)	0	
None	17 (85.0)	3 (15.0)	0.511
Microorganism isolated			
Staphylococcus aureus	8 (61.5)	5 (38.5)	
Sterile	5 (71.4)	2 (28.6)	
Not received	7 (63.6)	4 (36.4)	
Coagulase-negative Staphylococcus	19 (90.5)	2 (9.5)	
Pseudomonas aeruginosa	7 (87.5)	1 (12.5)	
Klebsiella pneumoniae	1 (50.0)	1 (50.0)	
Enterococcus sp.	3 (100.0)	0	
Enterobacter	0	1 (100.0)	
Proteus vulgaris	1 (100.0)	0	
Acinetobacter baumannii	1 (100.0)	0	
Escherichia coli	1 (100.0)	0	0.263
Catheter duration			
<10 days	16 (84.2)	3 (15.8)	
>10 days	37 (74.0)	13 (26.0)	0.369
General signs			
Present	29 (87.9)	4 (12.1)	
Absent	24 (66.7)	12 (33.3)	0.035

CKD, chronic kidney disease; HTN, hypertension; IS, immunosuppression.

hemodialysis cohorts reported in the literature [5,24–29]. Younger age may confer immunological advantages facilitating infection clearance [30] and tolerance of conservative management approaches.

Microbial ecology: the predominance of CoNS (30.1% of isolates) and susceptible *S. aureus* (18.8%) created favorable conditions for catheter salvage. CoNS are recognized as low-virulence organisms [21,22] frequently amenable to treatment without device removal when appropriate antibiotics are administered. Even *S. aureus* infections, traditionally considered an indication for catheter removal per KDOQI 2019 guidelines, responded successfully to antibiotic therapy in our experience, whether methicillin-susceptible or methicillin-resistant strains.

Deviation from established guidelines

Our conservative approach to *S. aureus* and *P. aeruginosa* infections represents a notable divergence from 2019 KDOQI guidelines, which recommend catheter removal for these pathogens. This deviation warrants justification. We based our decision on two key considerations: (a) recognition that antimicrobial susceptibility patterns vary geographically and temporally [23], with our local surveillance demonstrating favorable susceptibility profiles; (b) practical constraints in our resource-limited setting where premature catheter removal could leave patients without dialysis access.

Importantly, *P. aeruginosa* prevalence in our center (11.6% of isolates) exceeded rates typically reported in the literature (2–8%) [31–36], yet all strains remained antibiotic-susceptible and infections resolved with targeted therapy alone. This underscores that local epidemiology, rather than universal protocols, should guide management decisions, particularly in resource-constrained environments.

The single exception to our conservative approach was *A. baumannii*, for which we maintained a policy of systematic catheter removal. This decision reflected the organism's propensity for multidrug resistance.

Our findings suggest that in resource-limited settings where blood culture capability is restricted, a risk-stratified approach to CVC-associated infections may be feasible. Conservative management appears appropriate for carefully selected patients with: (a) jugular catheter placement, (b) isolated local signs without systemic manifestations, (c) susceptible organisms (particularly CoNS, susceptible *S. aureus* or *Pseudomonas*), and (d) adequate immune function. Conversely, systemic signs should prompt strong consideration for catheter removal, as this was the only significant predictor of removal necessity in our analysis.

This approach is particularly relevant for low-income and middle-income countries where dialysis access is limited, blood culture supplies are inconsistent, and premature catheter removal may leave patients without life-sustaining dialysis access. However, implementation requires robust clinical assessment, appropriate empirical antibiotic coverage based on local microbiology, and capability for close monitoring and prompt intervention if conservative management fails.

Conclusion

This study demonstrates that conservative management of CVC-related infections is feasible in selected hemodialysis patients, achieving excellent outcomes with 100% clinical resolution and zero mortality in our cohort. A risk-stratified approach prioritizing catheter retention for jugular sites with local-only manifestations and susceptible organisms, while systematically removing femoral catheters, catheters in immunocompromised patients, and infections with systemic signs or resistant pathogens, appears to balance infection control with preservation of vascular access.

This experience provides preliminary evidence that with appropriate patient selection, optimized empirical antibiotics based on local epidemiology, and vigilant monitoring, catheter salvage may represent a viable alternative to routine removal in carefully selected cases of CVC-related infection in hemodialysis patients.

Study limitations

First, as this was a retrospective study conducted at a single center, the findings should be interpreted with caution and may not be generalizable to other settings. Our findings reflect specific local factors including microbial ecology, patient demographics, clinical protocols, and resource constraints that may not be replicated elsewhere. Prospective validation in diverse settings is needed.

Second, our relatively small sample size (69 infected catheters) restricted statistical power of the study.

Finally, we did not perform cost-effectiveness analysis comparing conservative versus removal strategies. While catheter retention theoretically reduces costs associated with new access placement, we did not quantify these potential savings or compare them with the costs of prolonged antibiotic therapy and monitoring.

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Conflicts of interest

There are no conflicts of interest.

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