ORIGINAL RESEARCH

Management Outcomes after Image-guided Percutaneous Biopsy for Suspected Vertebral Osteomyelitis-Discitis

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ABSTRACT

BACKGROUND AND PURPOSE: Studies show a modest yield for image-guided biopsy of suspected vertebral osteomyelitis-discitis. Many studies evaluate factors to improve diagnostic yield, and few studies assess how biopsy results impact clinical management. We aim to evaluate the impact of biopsy results on clinical management in suspected vertebral osteomyelitis-discitis.

MATERIALS AND METHODS: We performed a retrospective study of patients who underwent image-guided biopsy for suspected vertebral osteomyelitis-discitis. Data collected included risk factors, imaging findings, laboratory values, antibiotics, biopsy procedure details, microbiology and pathology results and clinical course. Factors assessed for management change included whether biopsy results affected antibiotic type or course, decision to start or stop antibiotics, surgical decisions or if an alternate diagnosis was determined.

RESULTS: 310 biopsies were included. Biopsy yield with true positive culture results was 34% (104/310) and similar for patients on antibiotics (36%, 34/94) and off antibiotics (32%, 66/204). Yield was greater when disc was sampled (36%, 82/228) versus bone only (8%, 2/24) and with aspiration of disc and/or bone (42%, 39/92) versus core only (29%, 56/193). With positive blood cultures prior to biopsy, biopsy yield was 50% (22/44) with concordance and discordance rates of 75% (18/24) and 17% (4/24) respectively, and 8% (2/24) of positive biopsy results deemed contaminants. Management was affected in 36% (113/310) of all biopsies and in 78% (81/104) of biopsies with a positive culture result. No management change occurred in 57% (177/310) of biopsies. Management change was unclear in 6% (20/310). Biopsy results changed antibiotics in 27% (85/310). Management change occurred in 23% (10/44) of cases with prior positive blood culture compared to 41% (93/233) without a prior culture source (P = 0.024). Negative culture results influenced management in 16% (32/194).

CONCLUSIONS: Image-guided biopsy for vertebral osteomyelitis-discitis has a meaningful impact on management despite modest yield. Greatest management impact is seen with positive culture results, no prior culture source and patients not on antibiotics at the time of biopsy. Biopsy culture yield is not affected by preceding antibiotics, and yield is greater with disc sampling and aspiration.

ABBREVIATIONS: VO = vertebral osteomyelitis-discitis; WBC = white blood cell count; ESR = erythrocyte sedimentation rate; CRP = C-reactive protein; MC = management change; NMC = no management change; UC = unclear management change; Abx = antibiotics

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SUMMARY SECTION

PREVIOUS LITERATURE: Image-guided biopsy for diagnosis of vertebral osteomyelitis-discitis (VO) has been studied to evaluate factors to improve diagnostic yield. Image-guided biopsy has modest yield (27%)[5] and sensitivity (46-52%)[5-6]. Studies report biopsy influences management of VO in 9-50% of cases with varying results especially in the setting of culture-negative cases[3, 8-10].

KEY FINDINGS: Biopsy results changed management in 36% of cases, with 78% of positive cultures impacting antibiotic therapy. Disc sampling and aspiration yielded higher positive culture results. Antibiotics before biopsy did not impact yield, but management change was greater in patients not on antibiotics and with no prior culture source.

KNOWLEDGE ADVANCEMENT: This study shows image-guided biopsy meaningfully impacts management of VO, especially when no prior organism is identified and patients are not on antibiotics. We highlight biopsy yield is improved with disc sampling and aspiration, and yield is not significantly affected by prior antibiotic use.

INTRODUCTION

Vertebral osteomyelitis-discitis (VO) is an infection of the intervertebral disc and vertebrae, usually acquired hematogenously. *Staphylococcus aureus* is the predominant pathogen in Western countries and *Mycobacterium tuberculosis* is the most common worldwide[1]. Symptoms are vague, most commonly include pain, and progress insidiously over weeks[1,2]. Laboratory assays and imaging supplement clinical suspicion to establish the diagnosis. When no organism is identified by blood culture, image-guided biopsy is performed to identify a causative organism[2]. In patients with high clinical suspicion, empiric antimicrobial therapy is often initiated before microbiologic diagnosis[2]. Regardless of antimicrobial treatment, the yield of a percutaneous biopsy is modest[3-5], with positive microbiology results in 27%[5] and biopsy sensitivities of 46-52%[5-6].

The limited yield of image-guided biopsy and the initiation of empiric antibiotics before microbiologic diagnosis raise consideration of the value of biopsy and how to optimize it. A study on image-guided biopsies for suspected osteomyelitis throughout the body found biopsy cultures influencing treatment in 9%[7]. In studies evaluating biopsies for VO, reported management impact ranges from 9-50%[3,8-10].

We aim to expand upon prior studies to evaluate the yield and therapeutic impact of image-guided biopsy performed for suspected VO and identify which patients may or may not benefit from biopsy.

MATERIALS AND METHODS

Following Institutional Review Board approval, we performed a multi-site retrospective review of adult patients who underwent image-guided biopsy for clinically suspected VO from February 1998 to July 2023.

We searched radiology and pathology reports in the Illuminate InSight^{TM} software with keywords including spinal levels ("C2", "T1", etc.), "biopsy" and "osteomyelitis". CT and fluoroscopic biopsies for suspected VO were included, while biopsies for non-infectious processes were excluded. Patient demographics, medical history, imaging findings, laboratory values, biopsy details, microbiology and pathology results, antibiotic regimen, clinical course, and management changes were recorded from the medical record. Management change factors assessed included biopsy results' impact on antibiotic type or course, initiating or stopping antibiotics, surgical decisions or determining alternate diagnoses.

Over the 25-year period, different tissue processing methods, media and vendors were used across the sites. All employed routine era-appropriate culture techniques. Biopsies were processed using a stomacher machine or plastic tube grinder to homogenize along with sterile saline or broth if needed. Generally, aerobic cultures were incubated at 35°C in 5% CO2 for 5 days, aerobic plates (if performed) incubated for at least 4 days, and thioglycollate broth incubated for 14 days. Starting in 2016, some homogenates were inoculated into blood culture bottles (BD BACTEC Plus Aerobic/F medium and BD BACTEC Lytic/10 Anaerobic/F medium) and incubated on the BACTEC 9240/FX instruments (BD Diagnostic Systems) for 14 days. PCR were not routinely used, though available on request.

The Chi-squared test was used to compare proportions between independent proportions, and the two-sample T-test was used to compare means. Agreement between prior culture sources and biopsy culture results was evaluated using Cohen's Kappa. Statistical analysis was performed using Microsoft Excel, MedCalc for Windows, version 19.4 (MedCalc Software, Ostend, Belgium), R version 4.2.2 using package *irr*. All statistical tests were two-sided and a p-value < 0.05 was considered statistically significant. In subgroup analysis of variables, cases with missing data were excluded. This study follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (supplemental material).

RESULTS

310 image-guided biopsies of disc, vertebra and/or paraspinal tissue for suspicion of VO were included amongst 297 unique patients. Twelve patients had multiple biopsies: 9 patients underwent repeat biopsies for the same presentation, 2 patients had two separate presentations at different time points, and 1 patient had a repeat biopsy for the same presentation and another separate presentation at a different time point. Amongst the unique patients were 111 females and 186 males with a mean age of 65.55 years (SD 12.71).

Imaging Findings

Imaging reports before biopsy were available for 94% (290/310): both MR and CT reports were available in 28% (88/290), MR only in 54% (167/290), and CT only in 11% (35/290). Seventy-nine percent (231/290) of reports favored VO, 14% (40/290) were equivocal, and 7% (19/290) favored non-infectious diagnoses. Biopsy was recommended in 5% of reports (14/290). Figure 1 shows imaging of a true positive VO case.

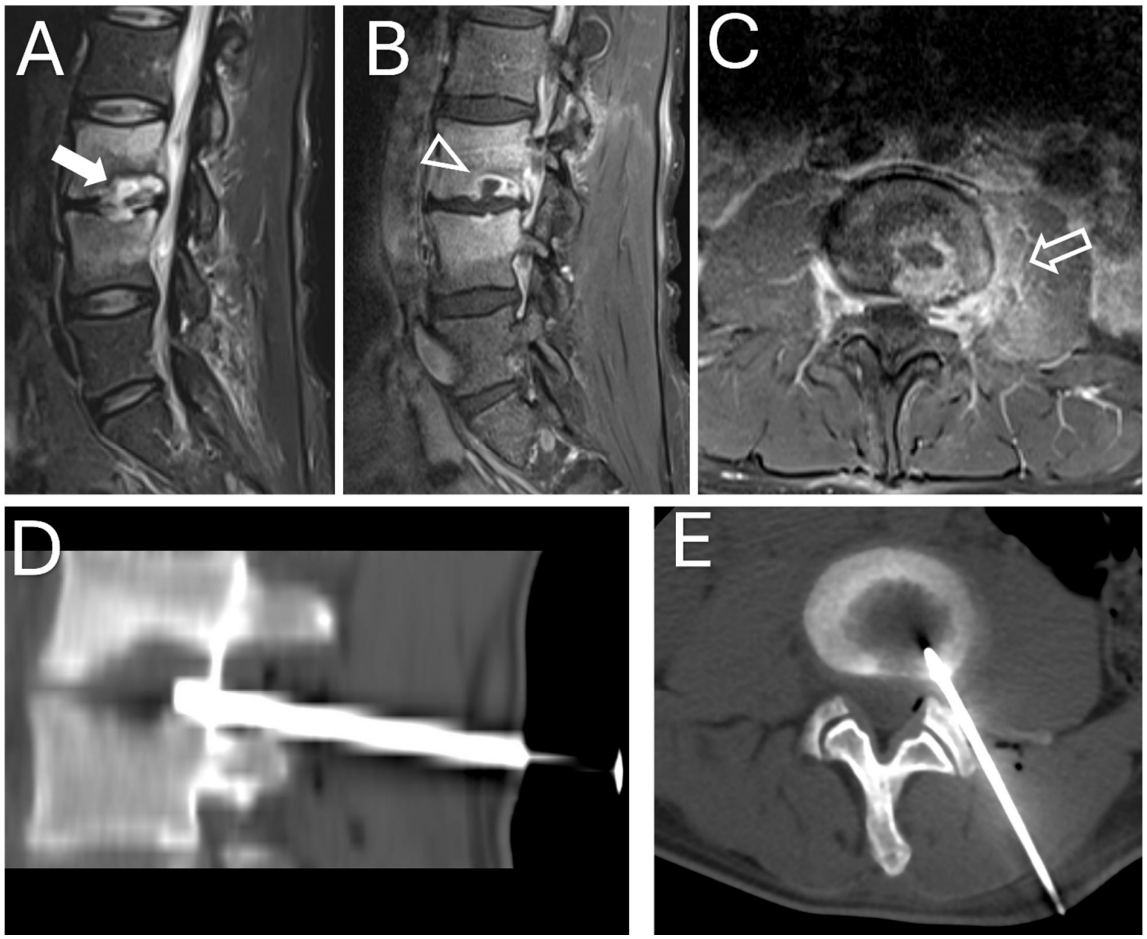

FIG 1. Sagittal STIR (A), sagittal post-contrast T1 (B), axial post-contrast T1 (C) MR sequences demonstrate imaging of L3-L4 vertebral osteomyelitis-discitis with disc-endplate irregularity, T2 hyperintensity centered within the disc (white arrow) extending in the adjacent vertebral bodies, peripheral enhancement of the irregular disc and endplates (outline arrowhead) with enhancement of the vertebral bodies and the paraspinous tissues (outline arrow). CT-guided biopsy with oblique sagittal (D) and axial (E) images show biopsy needle sampling of the disc-endplate margin.

Lab Values

White blood cell (WBC) count was available for 255 patients, with average of 8.5 x 10^9/ L (SD 7.69) within normal range (4-11 x 10^9/ L). WBC was abnormal in 22% (55/255) with 39 having elevated WBC and 16 having low WBC. Erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) were available in 226 and 239 cases, respectively. Average ESR was 46.6 mm/hr (SD 31.5, normal <20 mm/hr) with elevated ESR in 77% (174/226). Average CRP was 49.1 mg/dL (SD 60.2, normal < 8 mg/L) with elevated CRP in 78% (187/239). Positive blood cultures were documented in 14% (44/310) before biopsy, and 11% (33/310) had other positive culture/infection sources (urine, joints, wound, sputum, serology, prior biopsy).

Biopsy Procedure Details

Biopsy reports were available in 309 of 310 cases (details summarized in Table 1). CT and fluoroscopic guidance were used for 53% (165/309) and 47% (144/309), respectively. Distribution by level was 7% (21/310) cervical, 33% (102/310) thoracic, and 60% (187/310) lumbar.

Needle sizes were reported in 245 cases ranging from 9-22g. Many biopsies used multiple needle gauges, including the introducer to collect samples. The most common (51%, 124/245) needle size was 14g with 11g/13g introducers. Of the core biopsies, 68% (197/291) quantified sample number (range 1-13; mean 4.0 (SD 2.1)), and others reported “multiple” or “several” core samples without quantification. Sample length was not routinely reported. Aspiration volume was reported in 45% (52/116) ranging from 0.5-15 mL and mean 3.1 mL (SD 3.0).

Table 1: Biopsy Procedure Details.

Procedure Detail	Category	Value
Modality	CT	53% (165/309)
	Fluoroscopy	47% (144/309)
Level	Cervical	7% (21/310)
	Thoracic	33% (102/310)
	Lumbar	60% (87/310)
Tissue	Disc + Bone	40% (123/309)
	Bone Only	8% (24/309)
	Disc Only	34% (105/309)
	Paraspinal + Bone/Disc	9% (29/309)
	Paraspinal Only	0.3% (1/309)
	Unspecified	9% (27/309)
Sample	Core + Aspirate	32% (98/309)
	Core Only	62% (193/309)
	Aspirate Only	6% (18/309)
Primary Needle Size	9-13g	14% (42/309)
	14g	40% (124/309)
	15-17g	7% (21/309)
	18-19g	13% (42/309)
	20-22g	5% (16/309)
	Unspecified	21% (64/309)
Core Samples	Average Number	4.00 (SD 2.1)
Aspiration	Average Volume	3.125 (SD 3.0)

Complications were documented in 1.6% (5/310), 3 with CT and 2 with fluoroscopic guidance, including prolonged bleeding (n=1), nausea (n=1), pain greater than expected (n=2), and a linear fracture through the adjacent facet joint (n=1).

Biopsy Yield

Biopsy yielded a positive culture result in 38% (119/310) of cases, with 13% (15/119) deemed contaminants by the clinical team, resulting in a 34% (104/310) true positive culture yield. Negative cultures were documented in 58% (179/310). Culture results were unavailable for 4% (12/310) due to lost specimens, non-submission, or patient death or discharge. Online Supplemental Data provides clinical and procedure information with relation to biopsy yield.

As shown in Online Supplemental Data, there was no significant difference in biopsy yield with respect to modality, needle size, sample number, and aspirate volume. Biopsy needle sizes (9-13g, 14g, 15-17g, 18-19g, 20-22g) showed no significant yield difference, with the lowest yield of 31% (38/124) in the 14g group and highest yield of 38% (8/21), in the 15-17g group (P = 0.6). Core-only biopsies of bone and/or disc had significantly lower yield (29%, 58/193) compared to disc/bone aspirate with or without cores (42%, 39/92), (P = 0.002). Aspiration-only resulted in yield of 56% (10/18). Bone-only samples had significantly lower yield versus disc with or without bone (yield 36%, 82/228), (P = 0.006). Yield with paraspinal tissue/fluid sampling was 43% (13/30) compared to 33% (84/252) without paraspinal sampling (P = 0.3).

Thirty percent (94/310) of patients were receiving antibiotics at the time of biopsy. Biopsy yield was 36% (34/94) on antibiotics versus 32% (66/204) not on antibiotics (P = 0.49). Thirteen patients were on long-term antibiotics for prophylaxis or treatment of other infections, with 16% (2/13) having a positive culture result. Excluding long-term antibiotics (> 6 weeks), mean antibiotic duration before biopsy was 3.69 days (SD 3.01) for positive cultures versus 6.35 days (SD 8.07) for negative cultures (P = 0.08).

Seventy-seven cases had other positive culture sources, including 44 positive blood cultures. For positive blood cultures, 55% (24/44) had a positive biopsy culture, with 75% (18/24) growing the same organism, 17% (4/24) growing different organisms, and 8% (2/24) growing contaminant organisms. Cohen's Kappa score for agreement between blood and biopsy cultures was 0.34 (95% CI -0.02, 0,70). With any prior positive culture result (blood, urine, wound, etc.), 49% (38/77) had positive biopsy culture with 68% (26/38) growing the same organism, 18% (7/38) growing different organisms and 13% (5/38) growing contaminant organisms. The Cohen's Kappa score for all prior cultures compared to biopsy results was 0.39 (95% CI 0.02, 0.65). Positive biopsy yield was 50% (22/44) with prior positive blood cultures compared to 30% (71/233) with no prior culture source (P = 0.01). Figure 2 lists the isolated organisms from biopsy.

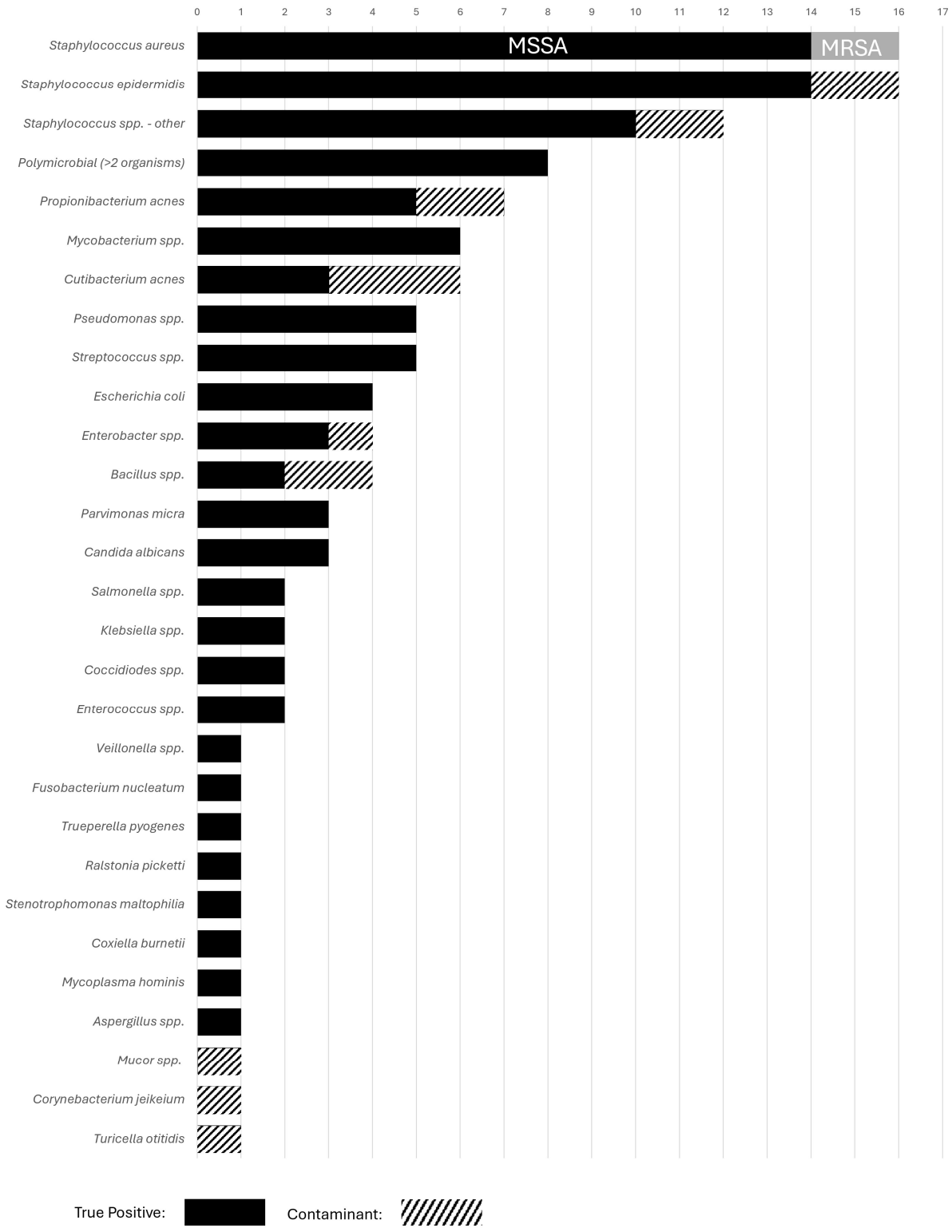

FIG 2. Isolated Organisms on Biopsy: True positive (solid black), Contaminant (striped).

Management Outcomes and Clinical Diagnosis

Biopsy results changed management (MC) in 36% (113/310) of all cases and did not change management (NMC) in 57% (177/310). Management impact was unclear (UC) in 6% (20/310) due insufficient documentation or clinical complexity. Figure 3 categorizes management change related to biopsy results. Antibiotics were changed in 27% (85/310) of all cases. In positive biopsy cultures, management changed in 78% (81/104) when antibiotics were started or tailored based on the organism. Table 2 shows management change related to clinical variables.

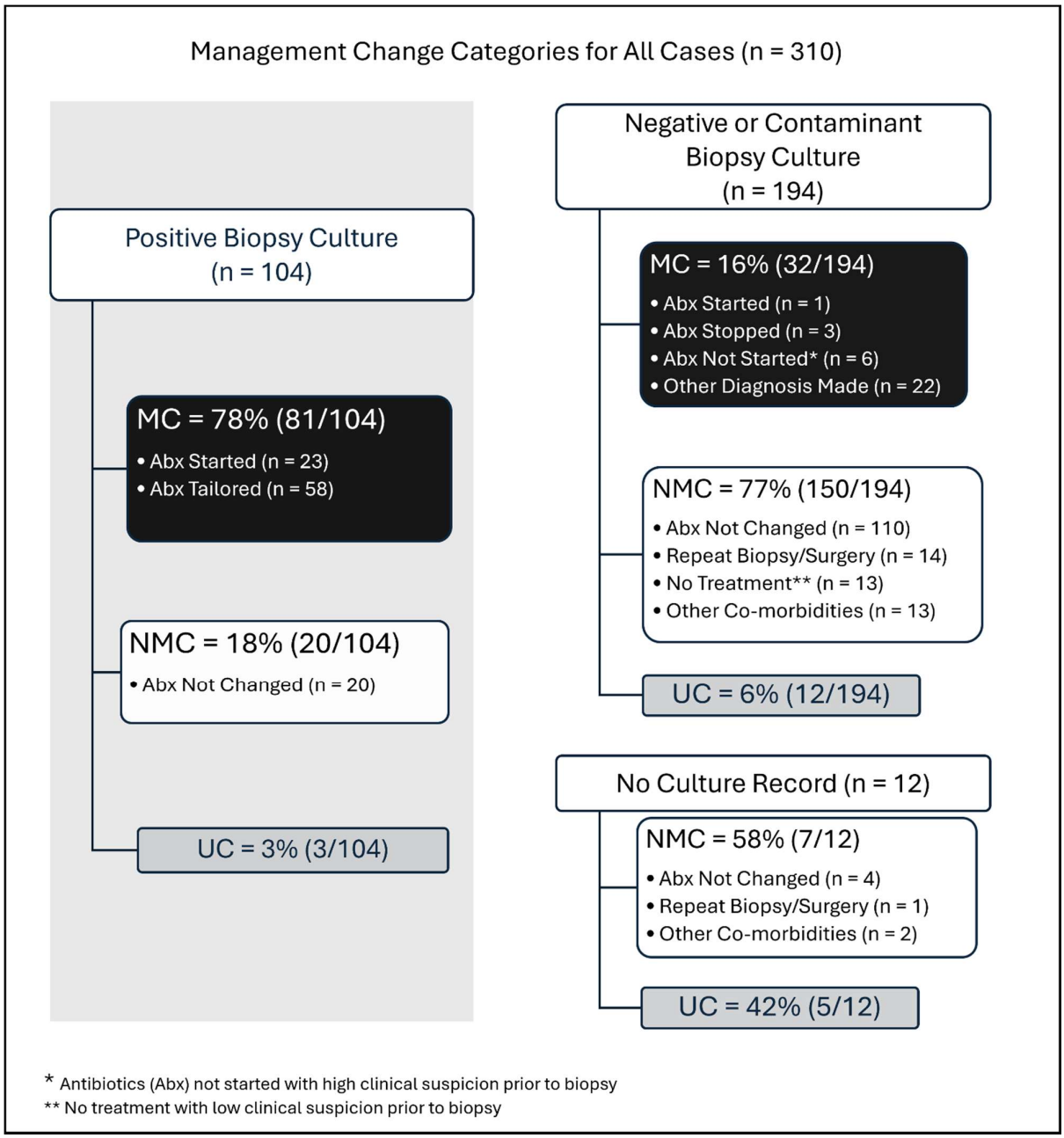

FIG 3. Management change categories for all cases.

Table 2: Clinical Information relating to Management Change

	Management Change (MC)	**No Management Change** (NMC)	**Unclear**	**P-value (MC vs. NMC)**
Biopsy				
All Biopsies	36% (113/310)	57% (177/310)	6% (20/310)	
Positive Culture	72% (81/113)	11% (20/177)	3% (3/104)	**P < 0.0001**
Negative Culture	27% (30/113)	79% (139/177)	6% (10/179)	**P < 0.0001**
Contaminant Culture	2% (2/113)	9% (11/177)	13% (2/15)	**P = 0.017**
Antibiotics				
On Antibiotics	19% (21/113)	40% (70/177)	3% (3/94)	**P = 0.0002**
No Antibiotics	78% (88/113)	57% (101/177)	7% (15/204)	**P = 0.0003**
Cultures				
Other culture positive (any source)	18% (20/113)	31% (55/177)	3% (2/77)	**P = 0.014**
Blood culture positive	9% (10/113)	19% (33/177)	2% (1/44)	**P = 0.021**
No other Culture Source	82% (93/113)	69% (122/177)	8% (18/233)	**P = 0.014**
Laboratory Data				
Abnormal WBC	13% (15/113)	23% (40/177)	0% (0/55)	**P = 0.04**
Elevated ESR and/or CRP	73% (82/113)	72% (128/177)	2% (5/215)	P = 0.85
Imaging				
Suspicious	75% (85/113)	75% (133/177)	6% (13/231)	P = 1.00
Equivocal	14% (16/113)	11% (20/177)	10% (4/40)	P = 0.45
Not suspicious	6% (7/113)	6% (11/177)	5% (1/19)	P = 1.00

For culture-negative or culture-contaminant cases, management changed in 16% (32/194), or 10% (32/310) of all cases, due to stopping antibiotics, not initiating antibiotics despite high clinical suspicion prior to biopsy, or determining another diagnosis. One case with negative culture had pathology consistent with acute-on-chronic inflammation, and antibiotics were started due to a presumed infection with false-negative culture. In these 32 cases, the sample was core only in 63% (20/32), aspirate only in 6% (2/32) and both core and aspirate in 31% (10/32). Sample location was bone only in 9% (3/32), disc only in 34% (11/32), bone and disc in 38% (12/32), paraspinal and bone/disc in 13% (4/32), and unspecified in 6% (2/32).

Biopsy results did not affect antibiotics in 57% (110/194) of culture-negative or culture-contaminant cases and 44% (134/310) of all cases treated with empiric antibiotics or antibiotics targeted to other culture sources. Antibiotics were not changed in 73% (32/44) of patients with positive blood cultures already on targeted therapy. Antibiotic changes with prior positive blood culture occurred with discordant biopsy results and inadequate antibiotic coverage (7%, 3/44), antibiotics held prior to biopsy with positive biopsy result (5%, 2/44), and broad-spectrum antibiotics narrowed after concordant or negative biopsy result (11%, 5/44). Excluding patients with no other prior culture source (Figure 4), management changed in 40% (93/233), significantly greater than 23% (10/44) with prior positive blood culture (P = 0.04). In patients not on antibiotics at biopsy, management changed for 41% (88/216), significantly greater than 22% (21/94) on antibiotics (P = 0.001).

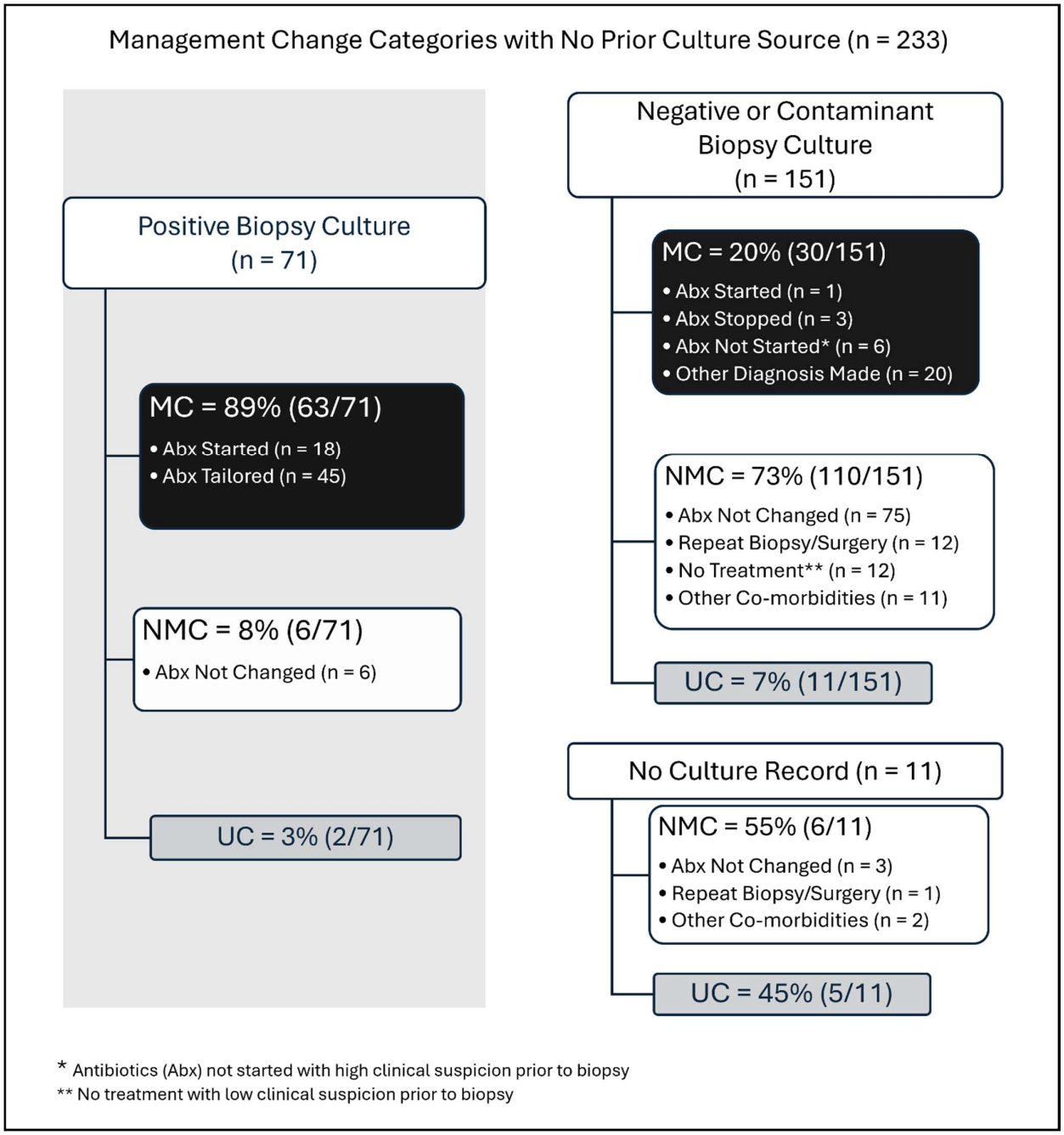

FIG 4. Management change categories with no prior culture source.

Culture-negative and culture-contaminant cases were deemed to not contribute to management change if repeat biopsy or surgery was needed (n = 14), in cases with low suspicion for VO prior to biopsy and no associated treatment (n = 11), and when clinical course was primarily influenced by co-morbidities (n = 19) such as other infection, malignancy, and/or cardiac arrest.

A final diagnosis of VO treated with antibiotics was documented in clinical notes of 70% (218/310) of cases, including the 104 culture-positive cases and 114 presumed false-negative cultures. VO was excluded based on clinical factors and biopsy results in 20% (62/310) with alternate diagnoses including degenerative (n = 19), trauma/fracture (n = 7), inflammatory/rheumatologic (n = 6), prior treated osteomyelitis (n = 4), post-radiation (n = 1), and unspecified (n = 25). The final diagnosis was unclear in 10% (30/310) of culture-negative or culture-contaminant cases in which treatment was also targeted to other pre-existing infections and co-morbidities. The concordance rate of initial imaging impression and final clinical diagnosis was 63% (184/290). Management change was not significantly different between the imaging suspicious, equivocal or not suspicious groups.

DISCUSSION

Diagnosing VO is challenging given its insidious onset, nonspecific symptoms, overlapping clinical features with non-infectious etiologies and low biopsy yield[3-6]. Ideal management requires isolation of a causative organism through blood culture or biopsy followed by targeted antibiotic therapy[2]. Many patients are started on empiric antibiotics prior to biopsy. Given these factors, we aimed to assess how image-guided biopsy results influence clinical management in suspected VO.

Similar to prior studies, we observed a suboptimal biopsy yield of 34% (104/310) [3-6], with *Staphylococcus aureus* being the most common isolated pathogen[1-2]. We observed a modest overall change in management (36%, 113/310) due to the biopsy results, similar to Winkler et al's 37.5 %[8] but variable from Kuo et al. (9%)[10] and Ang et al. (50%)[3]. Management was impacted in the majority (78%, 81/104) of culture-positive cases through tailoring of antibiotic regimens. This highlights the importance of optimizing biopsy methods for the greatest biopsy yield to impact management.

Even when an organism cannot be identified with biopsy, many patients are treated empirically if there is high clinical suspicion for VO as was the case in 57% (110/194) of the culture-negative or culture-contaminant biopsies. Despite 30% (94/310) of patients receiving antibiotics before biopsy, there was no significant difference in the biopsy yield based on short-term antibiotic exposure. Our results are in agreement with a recent meta-analysis by Chang et al[5] that reported no difference in microbiology sensitivities based on antibiotic exposure, though other studies report antibiotics influence culture yield[11]. Longer antibiotic duration (6.35 days) was associated with negative culture results compared to 3.69 days for positive culture results, though this difference did not reach statistical significance, suggesting that antibiotic status should not impact the decision to perform biopsy, but performing the biopsy sooner after initiating antibiotics may improve yield.

Higher biopsy yield (50%; 22/44) occurred in the setting of prior positive blood cultures. However, management change was significantly greater with no positive blood culture (MC 41%, 88/216) versus positive blood cultures (MC 23%, 10/44). This is likely because most patients with positive blood cultures (73%, 32/44) were on appropriate targeted antibiotics at biopsy with subsequent concordant or negative biopsy results that did not change therapy. Similarly, management change was greater in patients not on antibiotics at biopsy (MC 41%, 88/216) versus those on antibiotics (MC 22%, 21/94).

Fluid collection aspiration, disc biopsy (versus bone), withholding antibiotics, elevate CRP, and use of larger bore needles have been associated with higher diagnostic biopsy yield[3,4,11,12] though other studies question the importance of some of these factors[5]. We found disc sampling with or without bone (yield 36%, 82/228) and disc/bone aspiration with or without cores (yield 42%, 39/92) were significantly associated with higher yield than bone only (yield 8%, 2/24) or core only (yield 29%, 56/193). Highest yield (56%, 10/18) was with aspiration only, possibly due to discrete fluid collections rather than solid material. However, variable reporting prevented us from determining if aspiration was from a discrete fluid collection or disc space in most cases. Needle size varied (9g-22g), though most used large bore needles (14g), with no difference between positive and negative culture groups, contrary to Husseini et al's conclusions[12].

Management change occurred in 16% (32/194) of negative/contaminant culture results or 10% (32/310) of all cases, similar to Winkler et al (11.7%)[8]. Negative culture results influenced management when an alternate diagnosis was identified histologically. Core samples were crucial for identifying alternate diagnoses and ruling out infection.

With respect to image-guided biopsy for VO, the 2015 Infectious Disease Society of America (IDSA) guidelines[2] recommendations include the following: 1) defer image-guided biopsy when blood cultures are positive for *Staphylococcus aureus* or *S. lugdunensis*, or testing is positive for *Brucella* species in endemic regions; 2) obtain image-guided biopsy when a microbiologic diagnosis is not established from blood cultures or serology; 3) obtain pathology specimens to guide therapy, which can be informative when cultures are negative; and 4) withhold antimicrobial therapy prior to biopsy in stable patients to optimize culture sensitivity. These guidelines were not uniformly followed in this heterogenous multi-site retrospective study with a 25-year inclusion period, though our results support the first three listed recommendations. We found that short-term antibiotic administration did not impact biopsy yield, suggesting withholding antibiotics prior to emergent image-guided biopsy may not be necessary.

Biopsy yield is likely impacted by sample handling and laboratory processing. The IDSA recommends using anaerobic transport media and specimen delivery within two hours[2], but these protocols could not be verified in our study. The amount of tissue available for microbiology can limit culture recovery, as samples are often shared with pathology. The variability of procedural techniques and sample processing practices in this study is a limitation, but we believe our multicenter design without shared technical policies is reflective of general hospital practices, increasing the external validity of results. The inclusion of cases with variable imaging interpretations, procedural modalities, and target tissue types provides useful information which may have served as exclusion criteria in prior studies[8,10,11].

This study is limited by the subjective nature of deciding management change retrospectively, though we used objective measures related to antibiotic therapy to determine management change. Additionally, we were limited by variable reporting of biopsy technique, including tissue sampled, needle size, and sample number. Laboratory methods were not standardized across time and sites which could impact biopsy yield, and we could not determine which exact sample led to a positive diagnosis. These factors have been examined in prior studies and emphasize the benefit of standardized procedure reporting to optimize our understanding of impactful procedural practices. Future prospective studies could be performed to contemporaneously evaluate biopsy technique, laboratory methods and clinical scenarios resulting in the greatest management changes.

CONCLUSIONS

This study assessed how biopsy results influence clinical management of VO. Management change is greatest with positive biopsy culture results, no prior culture sources and among patients not on antibiotics at biopsy. These results support performing a biopsy when a causative organism has not been isolated from another source. Antibiotic therapy at the time of biopsy does not impact yield but may lead to less management change. Disc sampling and aspiration are associated with higher culture yield. Negative culture results also influence management, and core biopsy identifies alternate diagnoses.

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SUPPLEMENTAL FILES

Online Supplemental Data: Clinical Information relating to Biopsy Yield

	Positive Biopsy Culture*	Negative Biopsy Culture*	p-Value
All Biopsies	34% (104/310)	58% (179/310)	
Patient Characteristics**			
Age, mean (SD), years	64.36 (+/- 12.81)	65.95 (+/- 12.81)	P = 0.31
Female	33% (34/104)	42% (76/179)	P = 0.13
Male	67% (70/104)	58% (103/179)	P = 0.13
Immunosuppressed	14% (15/104)	18% (32/179)	P = 0.38
Type 2 Diabetes Mellitus	7% (7/104)	8% (15/179)	P = 0.76
Vertebral Level			
Cervical	8% (8/104)	7% (12/179)	P = 0.76
Thoracic	42% (44/104)	31% (55/179)	P = 0.06
Lumbar	50% (52/104)	65% (117/179)	**P = 0.01**
Laboratory Data			
WBC, mean (SD), x 10^9/ L	9.68 (+/- 12.16)	7.84 (+/- 3.26)	P = 0.06
Leukocytosis	13% (14/104)	13% (24/179)	P = 1.00
ESR, mean (SD), (mm/hr)	50.63 (+/- 32.48)	41.71 (+/- 30.36)	**P = 0.04**
Elevated ESR	68% (71/104)	54% (96/179)	**P = 0.02**
CRP, mean (SD), mg/dL	57.47 (+/- 64.01)	44.35 (+/- 58.64)	P = 0.11

Elevated CRP	74% (77/104)	58% (103/179)	**P = 0.01**
Antibiotics At Biopsy			
No Antibiotics	63% (66/104)	68% (122/179)	P = 0.73
On Antibiotics	33% (34/104)	28% (50/179)	P = 0.37
Short-term (< 6 weeks) antibiotic duration mean (SD), days	3.69 (SD 3.01)	6.35 (SD 8.07)	P = 0.08
Prior Cultures			
Other positive culture (all sources)	32% (33/104)	21% (38/179)	**P = 0.04**
Positive blood culture	21% (22/104)	11% (19/179)	**P = 0.02**
No other Culture Source	68% (71/104)	79% (141/179)	**P = 0.04**
Imaging Findings for VO			
Suspicious	82% (85/104)	72% (129/179)	P = 0.06
Not Suspicious	4% (4/104)	7% (12/179)	P = 0.30
Equivocal	11% (11/104)	13% (24/179)	P = 0.62
Procedure			
CT	54% (56/104)	53% (94/179)	P = 0.87
Fluoroscopy	46% (48/104)	47% (85/179)	P = 0.87
Core + Aspirate	37% (38/104)	28% (51/179)	P = 0.12
Core only	54% (56/104)	68% (121/179)	**P = 0.02**
Aspirate only	10% (10/104)	4% (7/179)	**P = 0.04**
Disc Only	41% (43/104)	33% (59/179)	P = 0.18
Bone Only	2% (2/104)	11% (20/179)	**P = 0.01**
Disc + Bone	38% (39/104)	39% (69/179)	P = 0.87
Paraspinal + Disc/Bone	12% (12/104)	8% (15/179)	P = 0.27
Average # Cores (SD)	3.79 (SD 1.79)	4.24 (SD 2.10)	P = 0.15
Average volume Aspiration (SD), mL	3.35 (SD 3.44)	2.44 (SD 1.69)	P = 0.25
Average biopsy gauge	15.1 (SD 2.3)	15.0 (SD 2.3)	P = 0.83

*Excluding culture results with contaminants or no record
**Including repeat patients with multiple biopsies

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No.
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	3-4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3-4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	3-4
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4
Bias	9	Describe any efforts to address potential sources of bias	3-4
Study size	10	Explain how the study size was arrived at	3
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	4
		(*b*) Describe any methods used to examine subgroups and interactions	4
		(*c*) Explain how missing data were addressed	4
		(*d*) If applicable, explain how loss to follow-up was addressed	NA
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5, Table 1
		(b) Indicate number of participants with missing data for each variable of interest	5-6
		(c) Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	Report numbers of outcome events or summary measures over time	5-6, Figure 3-4
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	5-7
		(*b*) Report category boundaries when continuous variables were categorized	NA
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	5-7
Discussion			
Key results	18	Summarise key results with reference to study objectives	9-12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	10-12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9-12
Generalisability	21	Discuss the generalisability (external validity) of the study results	11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	NA