



REVIEW ARTICLE

# Management of destructive *Candida albicans* spondylodiscitis of the cervical spine: a systematic analysis of literature illustrated by an unusual case

Josef Stolberg-Stolberg<sup>1</sup> · Dagmar Horn<sup>2</sup> · Steffen Roßlenbroich<sup>1</sup> ·

Oliver Riesenbeck<sup>1</sup> · Stefanie Kampmeier<sup>4</sup> · Michael Mohr<sup>3</sup> ·

Michael J. Raschke<sup>1</sup> · René Hartensuer<sup>1</sup>

Received: 30 March 2016 / Revised: 10 October 2016 / Accepted: 16 October 2016  
© Springer-Verlag Berlin Heidelberg 2016

## Abstract

**Purpose** *Candida* induced spondylodiscitis of the cervical spine in immunocompetent patients is an extremely rare infectious complication. Since clinical symptoms might be nonspecific, therapeutic latency can lead to permanent spinal cord damage, sepsis and fatal complications. Surgical debridement is strongly recommended but there is no standard antimycotic regime for postsurgical treatment. This paper summarizes available data and demonstrates another successfully treated case.

**Methods** The systematic analysis was performed according to the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines. PubMed and Web of Science were scanned to identify English language articles. Additionally, the authors describe the case of a 60-year-old male patient who presented with a *Candida albicans* induced cervical spondylodiscitis after an edematous pancreatitis and *C. albicans* sepsis. Anterior cervical corpectomy and fusion of C4-C6, additional anterior plating, as well as posterior stabilization C3-Th1 was followed by a

6-month antimycotic therapy. There was neither funding nor conflict of interests.

**Results** A systematic literature analysis was conducted and 4599 articles on spondylodiscitis were scanned. Only four cases were found reporting about a *C. albicans* spondylodiscitis in a non-immunocompromised patient. So far, our patient was followed up for 2 years. Until now, he shows free of symptoms and infection parameters. Standard testing for immunodeficiency showed no positive results.

**Conclusion** *Candida albicans* spondylodiscitis of the cervical spine presents a potentially life-threatening disease. To our knowledge, this is the fifth case in literature that describes the treatment of *C. albicans* spondylodiscitis in an immunocompetent patient. Surgical debridement has to be considered, following antimycotic regime recommendations vary in pharmaceutical agents and treatment duration.

**Keywords** Spondylodiscitis · *Candida albicans* · Antibiotic treatment · Cervical spine · Infection

✉ Josef Stolberg-Stolberg  
Josef.Stolberg-Stolberg@ukmuenster.de

<sup>1</sup> Department of Trauma, Hand and Reconstructive Surgery, University Hospital Münster, Waldeyerstraße 1, 48149 Münster, Germany

<sup>2</sup> Department of Pharmacy, University Hospital Münster, Münster, Germany

<sup>3</sup> Department of Medicine A, Hematology, Oncology and Pneumology, University Hospital Münster, Münster, Germany

<sup>4</sup> Institute of Hygiene, University Hospital Münster, Münster, Germany

## Introduction

With only about 100 cases having been reported worldwide [1], spondylodiscitis of the cervical spine caused by *Candida* species is a rare disease. The thoracic and lumbar spine are affected in 95% [2, 3] and it is usually found in immunocompromised patients [4]. Fungal spondylodiscitis is uncommon even in large series and usually accounts for 0.5–1.6%, and 6.9% of all spondylodiscitis cases in one report [5]. Another review found that *Candida albicans* was responsible for 62% of 59 cases of *Candida* species spondylodiscitis. However, cases of spondylodiscitis

caused by other *Candida* species, *C. tropicalis*, *C. glabrata*, *C. krusei*, *C. lusitaniae* and *C. parapsilosis* become increasingly prevalent [6]. *Candida* species spondylodiscitis is generally associated with infection arising from catheter placement, drug abuse, provision of parenteral nutrition, and in immunocompromised patients, opportunistic infections [7, 8]. However, the increasing use of invasive procedures such as insertion of central venous catheters, arterial lines, or Foley catheters has also led to a rising importance of *Candida* species spondylodiscitis after hospital-acquired septicemia [8, 9]. Early diagnosis can be crucial to prevent spread of infection, abscess formation, sepsis, and death. An estimated overall mortality of 15% was reported [2]. To prevent complications a prolonged antimycotic treatment is recommended and surgical debridement has to be considered [1]. We report the fifth reported case of a *C. albicans* spondylodiscitis of the cervical spine that was unusual because it occurred in an immunocompetent patient with no chronic disease or previous multiple trauma. This case is followed by a systematic literature review.

## Case report

A 60-year-old man came to our outpatient clinic complaining about chronic neck pain. Two months previously he had undergone cholecystectomy as treatment of an acute edematous pancreatitis. During his hospital stay, he contracted *C. albicans* septicemia for which he started a 3-week course of systemic fluconazole 400 mg per day. Shortly after discharge, he went to a local Thai massage to recover from hospital. Because of muscular tensioning and pain in the neck region and progressing symptoms he presented in our outpatient clinic.

## Clinical course

The patient had pressure pain in the region of the middle and lower cervical spine without signs of inflammation or neurological deficits. CT scans and magnetic resonance imaging (MRI) (Fig. 1) showed a spinal stenosis with destruction of C4–C6. The patient was immediately admitted. Blood tests showed marginally elevated signs for infection with C-reactive protein (CRP) 4.2 mg/dl (<0.5 mg/dl), leucocytes 9.74 K/ $\mu$ l. He received no preoperative antibiotic prophylaxis because tissue samples were to be taken intraoperatively for microbiological analysis.

## Surgery and postsurgical course

Anterior cervical corpectomy and fusion (ACCF) was done (Fig. 2), followed by a CT-navigated dorsal stabilization from C3–C5 to C7–Th1. Microbiological analysis of tissue

samples taken intraoperatively revealed *C. albicans* spondylodiscitis, and antimycotic therapy with liposomal amphotericin B (5 mg/kg/day) intravenously once a day was started. Four days later, kidney deteriorated and hepatotoxic effects after were recognized. Amphotericin was discontinued, and antimycotic therapy was changed to caspofungin (70 mg/day) intravenously. The patient was discharged on the 10th hospital day after his last surgery, and 2 months of intravenous administration were completed on an ambulant basis. The therapy was then changed to oral fluconazole (400 mg/day) for additional 5 months, and then discontinued. Thus, the patient received antimycotic treatment for 7 months after surgery, when he did not show any complaints or signs of infection, which was sustained through the most recent contact 2 years after surgery. Primary or secondary immunodeficiency was excluded by the analysis of quantitative immunoglobulins including IgG subgroups, complete blood count and lymphocyte subpopulations without pathologic findings.

## Analysis of literature

## Methods

A systematic analysis according to preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines [10] was done to identify cases of *Candida* spondylodiscitis of the cervical spine in immunocompetent patients. Using the search term “spondylodiscitis”, one reviewer (JS-S), searched the PubMed and Web of Science database on December 3, 2015. The dates of publication and language were not limited, except that only articles with abstracts in English were selected.

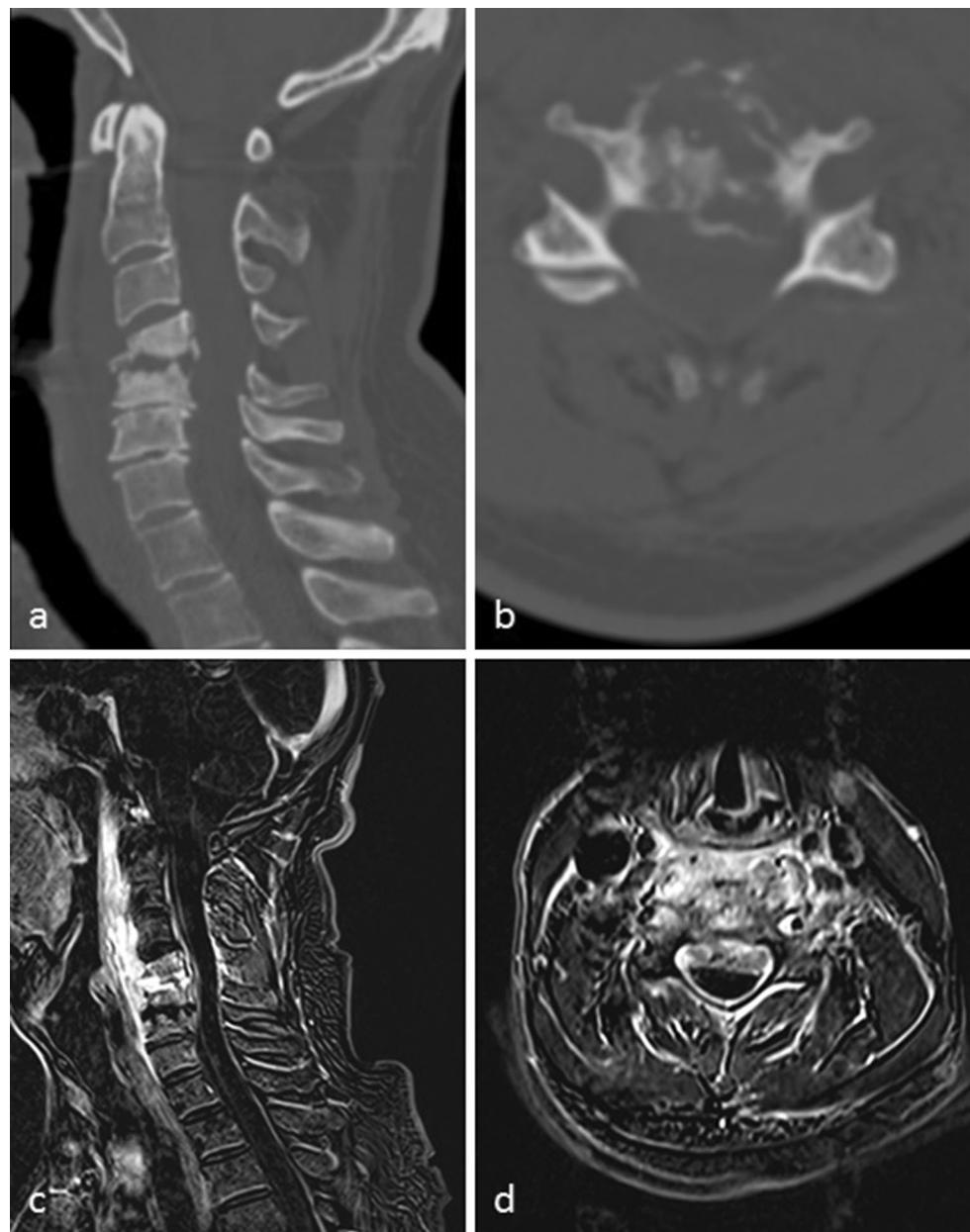
## Results

Of the 4599 titles and abstracts initially retrieved through data base searching (Fig. 3), 1461 cases were excluded due to doubling. Additionally, publications containing immunocompromised patients or different anatomic regions but the cervical spine were eliminated. Only four reports were identified as meeting search criteria.

## Discussion

### Symptoms

Early *Candida* spondylodiscitis can present unspecific. Due to its rare occurrence and failure to consider as possible diagnosis, delayed detection can put the patient at



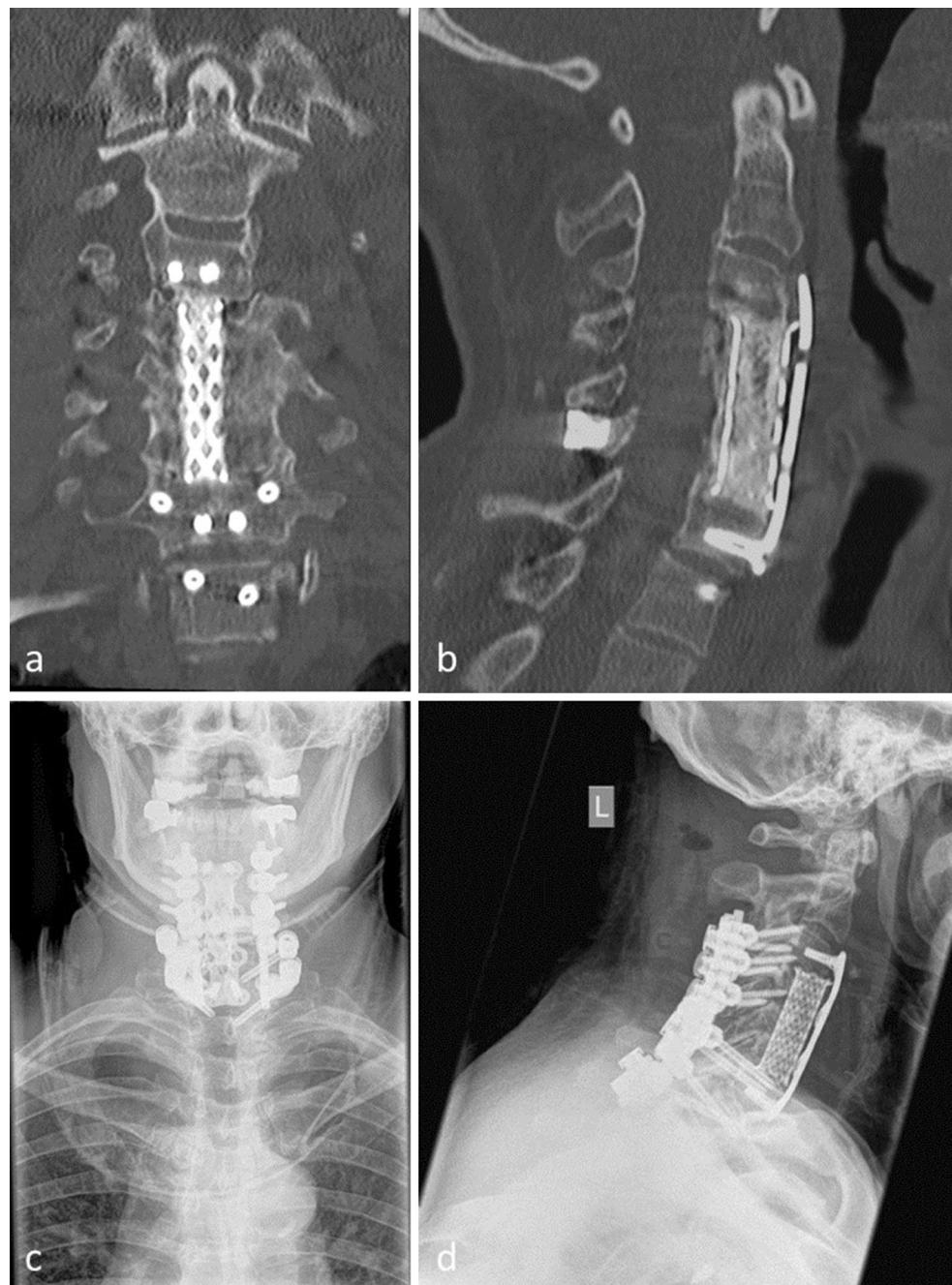
**Fig. 1** Preoperative CT scan in sagittal (a), axial (b) planes as well as MR-imaging in sagittal (c), axial (d) planes showing a spinal stenosis with destruction of C4–C6

significant risk. Chronic mechanical-type back and neck pain are described in literature [4]. Immunodeficiency, prior candidemia, use of steroids and antibacterial agents can allude to an earlier diagnosis. Fever is reported in 32% of the patients. At later stages, radicular pain, neurological symptoms including weakness in the extremities and decreased sensation, hyperreflexia and positive Babinski sign are reported. Fistulous connections to the gastrointestinal tract or airway from mostly malignant disease can also extend to the spinal cord [11, 12]. Extra-spinal

involvement including epidural abscess formation and psoas muscle irritation can lead to additional symptoms.

### Diagnosis

Clinical symptoms are not specific and can be greatly delayed. Erythrocyte sedimentation rate, leucocyte count and CRP are sensitive but show little specificity, and they do not account for immunodeficient patients [5, 11]. Blood cultures are reported to be false-negative in 24–50% of the

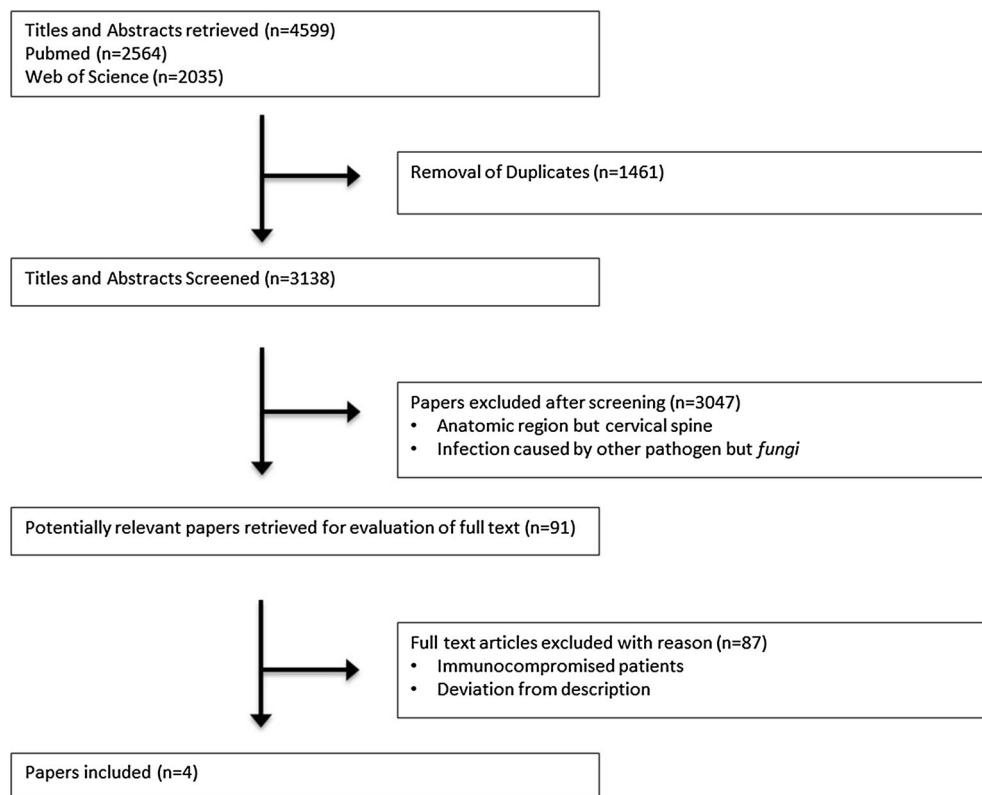


**Fig. 2** Postoperative CT scan in sagittal (a) and coronal (b) plane and X-ray in a.p (c) and lateral (d) projection showing anterior cervical corpectomy and fusion (ACCF) and dorsal stabilization from C3–5 to C7–T1

cases [9, 13]. Conventional radiologic imaging only shows late stage erosive and destructive spondylodiscitis [14]. CT-scanning can image bone changes but there are no characteristic alterations for fungal spondylodiscitis [15]. The gold standard is MR-imaging. The vertebral bodies and discs typically present hypointense in T1 and hyperintense in T2 [16]. Administration of contrast agent can improve sensitivity and specificity particularly in early

infections [5]. Other authors describe a hypointensity of the discs in T2 with normal intervertebral distance in patients with *Aspergillus* spp. and *Candida* spp. infection compared to bacterial spondylodiscitis in three patients. Further cases have to be examined to confirm these findings [17]. Therefore, specific differentiation of spondylodiscitis subtypes based on MRI finding seems to be difficult. Fluor-18-fluorodesoxyglucose-PET might be used in the future to

**Fig. 3** Flowchart outlining literature search results according to preferred reporting items for systematic reviews and meta-analyses (PRISMA)



distinguish between osseous and soft tissue infection [16]. However, reliable and concluding diagnosis has to be done by biopsy, histologic inspection and resistance testing.

### Surgical treatment

There are no treatment guidelines or evidence based recommendations for *Candida* induced spondylodiscitis in immunocompetent patients. Additionally, surgical treatment recommendations for immunocompromised patients are inconsistent within literature. Generally, conservative treatment can be considered in cases of overall critical condition and improvement of clinical symptoms [3, 18]. However, other authors record a need for surgical revision in 33% of the cases after conservative treatment attempt [8]. Minimally invasive surgery using a percutaneous suction aspiration technique has been tested unsuccessfully in cases of *Candida* induced spondylodiscitis [19]. Surgical debridement without stabilization is suggested in cases with recurrent blood stream infections and progressive neck pain. Epidural abscess formation, spinal instability, progressive deformity and neurologic deficits are frequently observed and make surgical intervention including debridement and stabilization indispensable, particularly at the cervical spine [8, 16, 20, 21]. The objective of surgery should be decompression of the spinal cord, debridement of

the infection, correction of axis deviations, pain reduction and immobilization for bone fusion via stabilization. Especially at the cervical spine, extensive debridement can oftentimes only be achieved by a ventral approach. At the thoracic and lumbar spine minimal invasive endoscopic approach may be considered [22, 23]. Osseous defects may be filled with a cage or autologous bone graft. There are numerous concepts describing potential stabilization. In case of multi-segmental defects an additional dorsal stabilization is recommended [16]. Implantation of antibiotic carriers or solely laminectomy for treatment neurologic symptoms is associated with high rates of complications [16, 24].

### Antimycotic treatment

The optimal medication and treatment duration for fungal spondylodiscitis are unknown. Again, there is no treatment regime for immunocompetent patients. Resistance testing and guided antifungal therapy seem to be obligatory as fungal species show different susceptibilities. Development of resistances among *Candida* species is controversially discussed. Antifungal drug resistance was considered less problematic in *Candida* species than in other pathogens. However, acquired resistances against echinocandins and azoles are advancing fast [2, 25]. On this occasion Bailly

et al. investigated a rise in minimum inhibitory concentrations in nearly all *Candida* species correlated with echinocandin consumption indicating developing resistance mechanisms [26]. These results confirm previous studies by Pfaller et al. in which the five most frequent isolated *Candida* species partially showed resistances against anidulafungin, caspufungin, micafungin, posaconazole and voriconazole isolated from intensive care unit (ICU) and non-intensive care unit (NICU) patients. Overall fluconazole resistance was here found to be 5% in ICU patient isolates and 4.4% in NICU patient isolates [27]. However, if there is no antifungal resistance, medication using amphotericin B was recommended as first line therapy until recently [11]. Due to nephrotoxic side effects, current guidelines of the Infectious Diseases Society of America altered the treatment regime to fluconazole for a minimum duration of 6–12 months or liposomal amphotericin B for several weeks followed by fluconazole for 6–12 months [18, 21]. Similar recommendations are made by The European Society for Clinical Microbiology and Infectious Disease [28]. According to our experiences in this case, caspofungin is an evenly effective alternative for initial intravenous therapy compared to amphotericin B (Table 1). As our case report suggests, consequent treatment duration after *C. albicans* induced sepsis may be an essential factor to prevent secondary complications and to treat fungal induced spondylodiscitis after surgery.

### Analysis of literature

Of 4599 titles and abstracts initially screened, the systematic analysis of literature found only four cases of *C. albicans* spondylodiscitis of the cervical spine in immunocompetent patients (Table 2) [4, 20, 29, 30]. The infection in these four cases and in the one that we describe in this report was cured. The most recent report by Moon et al. [30] describes the case of a 64-year-old women with a *C. albicans* induced spondylodiscitis C5–

C6. She was treated with an anterior interbody fusion followed by amphotericin B treatment for 2 weeks and fluconazole for 6 months. However, it has to be stated that chronic gastritis and pulmonary tuberculosis might have affected patient's resistance against pathogens. Voigt et al. [4] describe a cervical spondylodiscitis C5–C6 of a poly-traumatized patient that had undergone a bacterial-fungal mixed pneumonia. As in our case, a relatively short antifungal treatment of the preceding pneumonia occurred only for 2 weeks. Ventral spondylodesis, cage implantation and antifungal medication using fluconazole only for around 4 months cured the patient. Weber et al. [29] treated a 6-year-old girl with a *C. albicans* induced spondylodiscitis of the base of the skull and atlas bone. The child was successfully treated conservatively using amphotericin B for 1.5 months. However, it clearly has to be outlined that a myeloperoxidase deficiency led to a series of previous infections in this patient and probably contributed to the outbreak of the *C. albicans* infection. Wang et al. [20] suggest that early needle biopsy leads to early diagnosis and can prevent surgical debridement. In their case, a 51-year-old male patient suffered from a destructive spondylodiscitis C5–C6 after a urinary tract infection. Only 3 months later the advanced infection had to be treated by open debridement, dorsal fixation and amphotericin B for 6 months.

### Clinical decision making

Progressive back pain in combination with fewer, elevated inflammatory laboratory findings (CRP, leucocytes, ESR, blood cultures) and peripheral neurologic deficits are highly suggestive of a spinal infection. Patient's medical history including risk factors such as recent spinal intervention, catheter infection, drug abuse, parenteral nutrition, blood stream infections and immunodeficiency legitimate more generous diagnostic procedures

**Table 1** Available antimycotic drugs, dosing side effects and costs (€ = 0–400 Euro/day; €€ = 400–600 Euro/day; €€€ = 600–1300 Euro/day)

Antimycotic drug	Dosing	Side effects	Costs
Fluconazole	6 mg/kg daily	Nausea, headache, liver damage	€
Voriconazole	Initial 6 mg/kg q12 h, then 4 mg/kg q12 h	Liver damage, nausea, headache	€€€
Lipid formulation amphotericin B	3–5 mg/kg daily	Hypokalemia, kidney and liver damage, leucopenia, cardiac arrhythmias, hypotension, nausea	€€
Anidulafungin	100 mg daily	Headache, nausea, cardiac dysfunction	€€€
Caspofungin	70 mg/daily	Nausea, anemia, hypokalemia, cardiac dysfunction	€€€
Micafungin	100 mg daily	Nausea, leucopenia, tachykardia	€€€

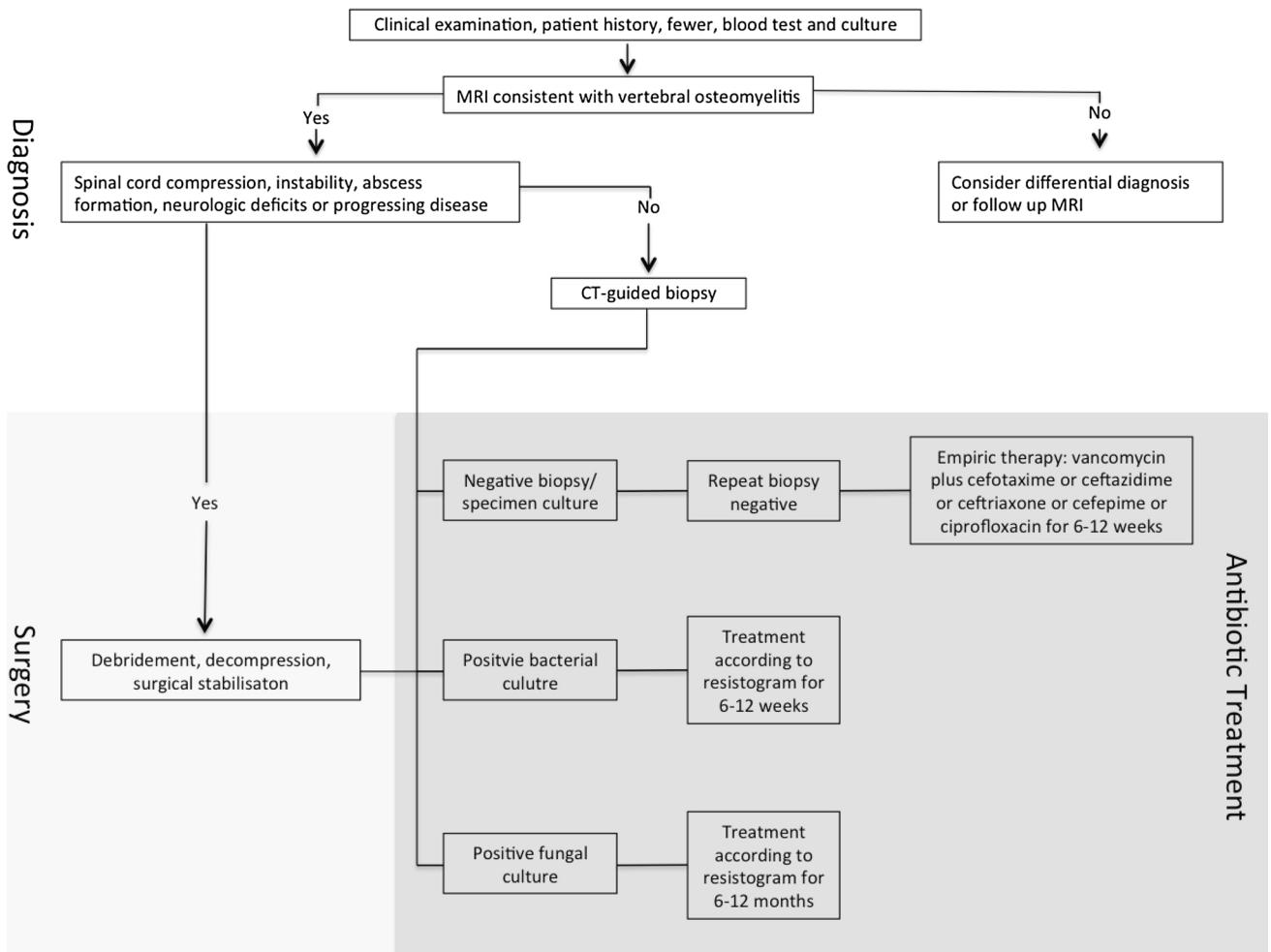
**Table 2** Reports of *C. albicans* spondylodiscitis of the cervical spine in immunocompetent patients

References	Segment	Age (years); sex	Complaint	Reason for	Risk factors	Treatment	Outcome
Weber et al. [29]	C1	6; female	Headaches and painful torticollis	Generalized hyperreflexia and plantar reflexes in extension, suggesting bilateral pyramidal syndrome	Myeloperoxidase deficiency	Amphotericin B (1.5 months)	Cured
Wang et al. [20]	C5/6	51; male	Neck pain and cervical radiculopathy	Erosion of C5 and intervertebral collapse of C5-C6 on plane radiograph and MRI	Central venous catheter, extensive urogenital surgery	Amphotericin B, dorsal instrumentation	Cured
Voigt et al. [4]	C5/6	36; male	Not applicable	Multiple trauma	Central venous catheter, pelvic surgery, <i>Candida</i> induced pneumonia	Fluconazol, anterior decompression, disectomy and fusion	Cured
Moon et al. [30]	C4–6	64; female	Neck pain	Spondylodiscitis and epidural abscess noted on MRI	Pulmonary tuberculosis, chronic gastritis	Anterior fusion with fibula graft C3-T1, amphotericin B (2 weeks), fluconazole (6 months)	Cured
Current report	C4–6	60; male	Chronic neck pain	Spinal stenosis with destruction of C4 to C6 noted on CT scans and MRI	<i>C. albicans</i> induced sepsis	Anterior fusion and dorsal stabilization Amphotericin B (4 days), Caspofungin (2 months), fluconazole (5 months)	Cured

[7, 8]. MRI with contrast agent is the gold standard to show radiologic evidence for spinal infections. If instability, spinal cord compression, abscess formation, neurologic deficits or progressing disease is shown, early surgical intervention needs to be considered. In the absence of these conditions and negative blood cultures, a computer tomography (CT)-guided needle biopsy should be performed (Fig. 4) [5, 16]. Despite routine microbiological diagnostic, fungal infections could be missed if not specifically investigated for. Consecutively, adequate therapy may be refrained or performed with avoidable delay. Pathogen directed antibiosis is desired and fungal infections require already mentioned specific antifungal regime for 6–12 months (Table 1). If biopsies are non-diagnostic, procedure should be repeated and empiric antibiotic treatment can be initiated. As most common pathogens are *Staphylococci*, *Streptococci* and gram-negative pathogens, an empiric therapy consists of vancomycin additional to any of the following antibiotics: cefotaxime, ceftazidime, ceftriaxone, cefepime or ciprofloxacin. A treatment duration of 6–12 weeks is recommended [18, 21]. Clinical follow-up should be directed by laboratory findings. Regular repeated imaging is not necessary unless there is a suspected worsening (Table 3).

## Conclusion

*Candida albicans* induced spondylodiscitis is a rare disease and usually found in immunocompromised patients [4]. Here, early suspicion, more frequent needle biopsy and spine MRI can avoid surgical intervention and late diagnosis [11, 20]. However, we describe the fifth case in an immunocompetent patient with no chronic disease or previous multiple trauma. Clinical symptoms are just as unspecific as for immunocompromised patients. General use of MRI probably is the most sensitive method to detect spondylodiscitis but with questionable capacity to distinguish between bacterial and fungal infections [31]. Common to these four cases was either chronic or repetitive underlying disease or both, or previous septicemia and a short term of antifungal therapy. Two of the patients [4, 30] had undergone long term intensive care and treatment for potentially life-threatening conditions before contracting *C. albicans* spondylodiscitis. In considering all four cases [4, 20, 29, 30] patients with *C. albicans* spondylodiscitis seemed to have a high risk of fungal septicemia and spread of infection from the blood. In three [4, 20, 30] of the four cases, *C. albicans* spondylodiscitis had been treated surgically by radical debridement and stabilization. Treatment



**Fig. 4** Decision making when spinal infection is suspected

**Table 3** Specific recommendations of the Infectious Diseases Society of America for *Candida* induced spondylodiscitis [18]

	Primary treatment	Alternative
<i>C. albicans</i>	Fluconazole 6 mg/kg daily for 6–12 months or amphotericin B (lipid formulation) 3–5 mg/kg daily for several weeks, then fluconazole for 6–12 months	An echinocandina (anidulafungin or micafungin, 100 mg daily) or amphotericin B (lipid formulation) 3–5 mg/kg daily for several weeks then fluconazole (6 mg/kg) daily for 6–12 months
<i>C. glabrata</i>	Echinocandin (anidulafungin or micafungin 200 mg, then 100 mg/day or caspofungin 70 mg/day) for 6–12 months	Transition to fluconazole or voriconazole is not recommended without confirmation of isolate susceptibility
<i>C. parapsilosis</i>	Fluconazole 6 mg/kg daily for 6–12 months	Not noted

with antifungal medication, amphotericin B or fluconazole for at least 6 months [16, 28] is equally important to surgery. Our review emphasizes the need to consider possible fungal spondylodiscitis even in immunocompetent patients and to include this in early diagnostic strategies. Long term

antifungal treatment and serious considerations for surgical debridement are necessary to reduce the high rate of mortality that has been reported in immunocompromised patients and not known about in immunocompetent patients [2].

**Acknowledgements** The authors contracted with Michael S. Altus, PhD, ELS, of Intensive Care Communications, Inc., Baltimore, MD, USA, to edit their revised manuscript. The authors thank Dr Altus for his excellent services. The authors maintained complete control over the direction and content of the manuscript.

### Compliance with ethical standards

**Conflict of interest** None of the authors has any potential conflict of interest.

### References

- Oksi J, Finntilä T, Hohenthal U, Rantakokko-Jalava K (2014) *Candida dubliniensis* spondylodiscitis in an immunocompetent patient. Case report and review of the literature. *Med Mycol Case Rep* 3:4–7. doi:10.1016/j.mmcr.2013.11.001
- Miller DJ, Mejican GC (2001) Vertebral osteomyelitis due to *Candida* species: case report and literature review. *Clin Infect Dis* 33:523–530. doi:10.1086/322634
- Hennequin C, Bourée P, Hiesse C, Dupont B, Charpentier B (1996) Spondylodiskitis due to *Candida albicans*: report of two patients who were successfully treated with fluconazole and review of the literature. *Clin Infect Dis* 23:176–178
- Voigt C, Lill H (2006) *Candida albicans* induced spondylodiscitis of the cervical spine of a polytraumatized patient. *Unfallchirurg* 109:998–1002. doi:10.1007/s00113-006-1143-0
- Gouliouris T, Aliyu SH, Brown NM (2010) Spondylodiscitis: update on diagnosis and management. *J Antimicrob Chemother* 65(Suppl 3):iii11–iii24. doi:10.1093/jac/dkq303
- Lewis RE, Klepser ME (1999) The changing face of nosocomial candidemia: epidemiology, resistance, and drug therapy. *Am J Health Syst Pharm* 56(16):525–533
- Garbino J, Schnyder I, Lew D, Bouchuiguir-Wafa K, Rohner P (2003) An unusual cause of vertebral osteomyelitis: *Candida* species. *Scand J Infect Dis* 35:288–291
- Hendrickx L, Van Wijngaerden E, Samson I, Peetersmans WE (2001) Candidal vertebral osteomyelitis: report of 6 patients, and a review. *Clin Infect Dis* 32:527–533. doi:10.1086/318714
- Arias F, Mata-Essayag S, Landaeta ME, Capriles CH, Pérez C, Núñez MJ, Carvajal A, Silva M (2004) *Candida albicans* osteomyelitis: case report and literature review. *Int J Infect Dis* 8:307–314. doi:10.1016/j.ijid.2003.12.006
- Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, Shekelle P, Stewart LA, Group P-P (2015) Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Syst Rev*. doi:10.1186/2046-4053-4-1
- Ramos A (2013) Vertebral osteomyelitis due to *Candida* species: a cohort study and review of the literature. *Open J Orthop* 3:83–89
- Gamaletsou MN, Kontoyiannis DP, Sipsas NV, Moriyama B, Alexander E, Roilides E, Brause B, Walsh TJ (2012) *Candida* osteomyelitis: analysis of 207 pediatric and adult cases (1970–2011). *Clin Infect Dis* 55:1338–1351. doi:10.1093/cid/cis660
- Cone LA, Byrd RG, Potts BE, Wuesthoff M (2004) Diagnosis and treatment of *Candida* vertebral osteomyelitis: clinical experience with a short course therapy of amphotericin B lipid complex. *Surg Neurol* 62:234–237. doi:10.1016/j.surneu.2003.11.018 (discussion 237)
- Bonakdar-pour A, Gaines VD (1983) The radiology of osteomyelitis. *Orthop Clin North Am* 14:21–37
- Pennisi AK, Davis DO, Wiesel S, Moskovitz P (1985) CT appearance of *Candida* diskitis. *J Comput Assist Tomogr* 9:1050–1054
- Müller EJ, Russe OJ, Muhr G (2004) Osteomyelitis of the spine. *Orthopade* 33:305–315. doi:10.1007/s00132-003-0603-2
- Williams RL, Fukui MB, Meltzer CC, Swarnkar A, Johnson DW, Welch W (1999) Fungal spinal osteomyelitis in the immunocompromised patient: MR findings in three cases. *AJNR Am J Neuroradiol* 20:381–385
- Pappas PG, Kauffman CA, Andes D, Benjamin DK, Calandra TF, Edwards JE, Filler SG, Fisher JF, Kullberg BJ, Ostrosky-Zeichner L, Reboli AC, Rex JH, Walsh TJ, Sobel JD, America IDSo (2009) Clinical practice guidelines for the management of candidiasis: 2009 update by the Infectious Diseases Society of America. *Clin Infect Dis* 48:503–535. doi:10.1086/596757
- Nagata K, Ohashi T, Ariyoshi M, Sonoda K, Imoto H, Inoue A (1998) Percutaneous suction aspiration and drainage for pyogenic spondylitis. *Spine (Phila Pa 1976)* 23:1600–1606
- Wang YC, Lee ST (2001) *Candida* vertebral osteomyelitis: a case report and review of the literature. *Chang Gung Med J* 24:810–815
- Barbari EF, Kanj SS, Kowalski TJ, Darouiche RO, Widmer AF, Schmitt SK, Hendershot EF, Holtom PD, Huddleston PM, Petermann GW, Osmon DR (2015) Executive summary: 2015 Infectious Diseases Society of America (IDSA) clinical practice guidelines for the diagnosis and treatment of native vertebral osteomyelitis in adults. *Clin Infect Dis* 61:859–863. doi:10.1093/cid/civ633
- Fountain SS (1979) A single-stage combined surgical approach for vertebral resections. *J Bone Joint Surg Am* 61:1011–1017
- Stone JL, Cybulski GR, Rodriguez J, Gryfinski ME, Kant R (1989) Anterior cervical debridement and strut-grafting for osteomyelitis of the cervical spine. *J Neurosurg* 70:879–883. doi:10.3171/jns.1989.70.6.0879
- Abramovitz JN, Batson RA, Yablon JS (1986) Vertebral osteomyelitis. The surgical management of neurologic complications. *Spine (Phila Pa 1976)* 11:418–420
- Fidel PL, Vazquez JA, Sobel JD (1999) *Candida glabrata*: review of epidemiology, pathogenesis, and clinical disease with comparison to *C. albicans*. *Clin Microbiol Rev* 12:80–96
- Bailly S, Maubon D, Fournier P, Pelloux H, Schwelbel C, Chapuis C, Foroni L, Cornet M, Timsit JF (2016) Impact of antifungal prescription on relative distribution and susceptibility of *Candida* spp.—trends over 10 years. *J Infect* 72:103–111. doi:10.1016/j.jinf.2015.09.041
- Pfaller MA, Messer SA, Moet GJ, Jones RN, Castanheira M (2011) *Candida* bloodstream infections: comparison of species distribution and resistance to echinocandin and azole antifungal agents in Intensive Care Unit (ICU) and non-ICU settings in the SENTRY Antimicrobial Surveillance Program (2008–2009). *Int J Antimicrob Agents* 38:65–69. doi:10.1016/j.ijantimicag.2011.02.016
- Cornely OA, Bassetti M, Calandra T, Garbino J, Kullberg BJ, Lortholary O, Meersseman W, Akova M, Arendrup MC, Arikan-Akdagli S, Bille J, Castagnola E, Cuenca-Estrella M, Donnelly JP, Groll AH, Herbrecht R, Hope WW, Jensen HE, Lass-Flörl C, Petrikos G, Richardson MD, Roilides E, Verweij PE, Viscoli C, Ullmann AJ, Group EFIS (2012) ESCMID\* guideline for the diagnosis and management of *Candida* diseases 2012: non-neutropenic adult patients. *Clin Microbiol Infect* 18(Suppl 7):19–37. doi:10.1111/1469-0691.12039
- Weber ML, Abela A, de Repentigny L, Garel L, Lapointe N (1987) Myeloperoxidase deficiency with extensive candidal osteomyelitis of the base of the skull. *Pediatrics* 80:876–879
- Moon HH, Kim JH, Moon BG, Kim JS (2008) Cervical spondylodiscitis caused by *Candida albicans* in non-

- immunocompromised patient. J Korean Neurosurg Soc 43:45–47.  
doi:[10.3340/jkns.2008.43.1.45](https://doi.org/10.3340/jkns.2008.43.1.45)
31. Lee SW, Lee SH, Chung HW, Kim MJ, Seo MJ, Shin MJ (2013) *Candida spondylitis*: comparison of MRI findings with bacterial and tuberculous causes. AJR Am J Roentgenol 201:872–877.  
doi:[10.2214/AJR.12.10344](https://doi.org/10.2214/AJR.12.10344)