

cated to isolate the infecting organism and allow for optimal treatment of the patient.

In a large case series of 1,980 patients, 74 infections were diagnosed [3]. The treatment algorithm consisted of six weeks of IV antibiotics if the patient was not fused. If the patient was fused, *Staphylococcus aureus* and gram-negative infections were treated with six weeks of IV antibiotics followed by six weeks of oral antibiotics with implant removal. In patients with propionibacteria and coagulase-negative *Staphylococcus*, four weeks of oral antibiotics were given. Oral antibiotics were not recommended as an initial treatment. Other studies have demonstrated the benefit of oral antibiotics as suppression therapy after treatment with surgical debridement and a course of IV antibiotics [4,5].

Multiple other studies have demonstrated the benefit of surgical debridement and IV antibiotics for infection [6]. In a consecutive case series of 2,391 patients, 46 cases of wound infection were identified and all treated with surgical debridement [7]. One series of 111 patients identified eight patients with postoperative infections after posterior lumbar interbody fusion [8]. All were treated with irrigation and debridement followed by four to six weeks of intravenous antibiotics followed by another six to nine weeks of oral antibiotics.

Multiple case series and expert opinion studies recommend avoiding oral antibiotics in suspected postoperative infection until culture samples are taken for better diagnosis and accurate treatment of these patients [9]. The majority of patients with established postoperative infection require surgical debridement.

REFERENCES

- [1] Cornett CA, Vincent SA, Crow J, Hewlett A. Bacterial spine infections in adults: evaluation and management. *J Am Acad Orthop Surg.* 2016;24(1):11-18. doi:10.5435/JAAOS-D-13-00102.
- [2] Foreman SC, Schwaiger BJ, Gempt J, et al. MR and CT imaging to optimize CT-guided biopsies in suspected Spondylodiscitis. *World Neurosurg.* 2017;99:726-734.e7. doi:10.1016/j.wneu.2016.11.017.
- [3] Collins I, Wilson-MacDonald J, Chami G, et al. The diagnosis and management of infection following instrumented spinal fusion. *Eur Spine J.* 2008;17(3):445-450. doi:10.1007/s00586-007-0559-8.
- [4] Kowalski TJ, Berbari EF, Huddleston PM, Steckelberg JM, Mandrekar JN, Osmon DR. The management and outcome of spinal implant infections: contemporary retrospective cohort study. *Clin Infect Dis.* 2007;44(7):913-920. doi:10.1086/512194.
- [5] Levi a D, Dickman Ca, Sonntag VK. Management of postoperative infections after spinal instrumentation. *J Neurosurg.* 1997;86(6):975-980. doi:10.3171/jns.1997.86.6.975.
- [6] Viola RW, King HA, Adler SM, Wilson CB. Delayed infection after elective spinal instrumentation and fusion: a retrospective analysis of eight cases. *Spine (Phila Pa 1976).* 1997;22(20):2444-2451. doi:10.1097/00007632-199710150-00023.
- [7] Weinstein MA, McCabe JP, Cammisa J. Postoperative spinal wound infection: a review of 2,391 consecutive index procedures. *J Spinal Disord.* 2000;13(5):422-426. doi:10.1097/00002517-200010000-00009.
- [8] Mirovsky Y, Floman Y, Smorgick Y, et al. Management of deep wound infection after posterior lumbar interbody fusion with cages. *J Spinal Disord Tech.* 2007;20(2):127-131. doi:10.1097/01.bsd.0000211266.66615.e5.
- [9] Chahoud J, Kanafani Z, Kanj SS. Surgical site infections following spine surgery: eliminating the controversies in the diagnosis. *Front Med (Lausanne).* 2014;1:7. doi:10.3389/fmed.2014.00007.

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QUESTION 2: Is there a role for the use of oral antibiotic in treatment of acute and chronic spinal infections?

RECOMMENDATION: There may be a role for highly bioavailable oral antibiotics in the treatment of acute and chronic spine infection in select circumstances.

LEVEL OF EVIDENCE: Moderate

DELEGATE VOTE: Agree: 100%, Disagree: 0%, Abstain: 0% (Unanimous, Strongest Consensus)

RATIONALE

Vertebral osteomyelitis

In vertebral osteomyelitis (spondylodiscitis) without an implant, experts recommend a treatment duration of 6 to 12 weeks [1]. However, a retrospective study over 10 years by Roblot et al. found no difference in relapse rate comparing 6 and 12 weeks of treatment [2]. An open label, non-inferiority, randomized, controlled trial by Bernard et al. firstly showed that 6 weeks was not inferior to 12 weeks. In both groups, intravenous treatment was only given for a median time of 14 to 15 days and was followed by an oral fluoroquinolone and rifampin combination or aminopenicillin (both regimens with high oral bioavailability) [3]. The authors could not see a difference in the proportion of treatment failure between patients given intravenous treatment for more than one week and those for less than one week.

Postsurgical infection with an implant

There are many studies in this field regarding optimal treatment duration and agents in spinal implant-associated infections, but

they are all retrospective with low levels of evidence. There are no up-to-date prospective and/or randomized studies published investigating the optimal duration of antibiotic treatment and the role of oral antibiotics in implant-associated spinal infections.

Most studies demonstrated successful treatment of spinal implant-associated infections with a total duration of six weeks [4-6]. If implants are not removed, reported durations of treatment are up to 12 weeks with intravenous treatment for 6 weeks, followed by oral antibiotic treatment for another 6 weeks [7,8].

Yet, regarding duration of intravenous treatment, there are no clear recommendations. Some studies treat intravenously for a prolonged time for up to four [8-10] or six weeks [4,11-13]. But there are also retrospective studies in which intravenous treatment was given for two weeks or less followed by oral antibiotics with good oral bioavailability [14]. Billieres et al. did a multivariate analysis on risk factors for relapse of infection and did not find an association with duration of total or intravenous antibiotic treatment [14]. Another study by Kowalsky et al. also concluded that duration of

intravenous treatment is no risk factor for neither acute nor chronic infections [15].

REFERENCES

- [1] Zimmerli W. Clinical practice. Vertebral osteomyelitis. *N Engl J Med*. 2010;362:1022–1029. doi:10.1056/NEJMc0910753.
- [2] Roblot F, Besnier JM, Juhel L, Vidal C, Ragot S, Bastides F, et al. Optimal duration of antibiotic therapy in vertebral osteomyelitis. *Semin Arthritis Rheum*. 2007;36:269–277. doi:10.1016/j.semarthrit.2006.09.004.
- [3] Bernard L, Legout L, Zürcher-Pfund L, Stern R, Rohner P, Peter R, et al. Six weeks of antibiotic treatment is sufficient following surgery for septic arthroplasty. *J Infect*. 2010;61:125–132. doi:10.1016/j.jinf.2010.05.005.
- [4] Roehrborn AA, Hansbrough JF, Gualdoni B, Kim S. Lipid-based slow-release formulation of amikacin sulfate reduces foreign body-associated infections in mice. *Antimicrob Agents Chemother*. 1995;39:1752–1755.
- [5] Viola RW, King HA, Adler SM, Wilson CB. Delayed infection after elective spinal instrumentation and fusion. A retrospective analysis of eight cases. *Spine*. 1997;22:2444–2450; discussion 2450–2451.
- [6] Kowalski TJ, Berbari EF, Huddleston PM, Steckelberg JM, Mandrekar JN, Osmon DR. The management and outcome of spinal implant infections: contemporary retrospective cohort study. *Clin Infect Dis*. 2007;44:913–920. doi:10.1086/512194.
- [7] Mirovsky Y, Floman Y, Smorgick Y, Ashkenazi E, Anekstein Y, Millgram MA, et al. Management of deep wound infection after posterior lumbar interbody fusion with cages. *J Spinal Disord Tech*. 2007;20:127–131. doi:10.1097/01.bsd.0000211266.66615.e5.
- [8] Collins I, Wilson-MacDonald J, Chami G, Burgoyne W, Vineyakam P, Berendt T, et al. The diagnosis and management of infection following instrumented spinal fusion. *Eur Spine J*. 2008;17:445–450. doi:10.1007/s00586-007-0559-8.
- [9] Falavigna A, Righesso O, Traynelis VC, Teles AR, da Silva PG. Effect of deep wound infection following lumbar arthrodesis for degenerative disc disease on long-term outcome: a prospective study: clinical article. *J Neurosurg Spine*. 2011;15:399–403. doi:10.3171/2011.5.SPINE10825.
- [10] Sponseller PD, LaPorte DM, Hungerford MW, Eck K, Bridwell KH, Lenke LG. Deep wound infections after neuromuscular scoliosis surgery: a multicenter study of risk factors and treatment outcomes. *Spine*. 2000;25:2461–2466.
- [11] Chen SH, Lee CH, Huang KC, Hsieh PH, Tsai SY. Postoperative wound infection after posterior spinal instrumentation: analysis of long-term treatment outcomes. *Eur Spine J*. 2015;24:561–570. doi:10.1007/s00586-014-3636-9.
- [12] Chaichana KL, Bydon M, Santiago-Dieppa DR, Hwang L, McLoughlin G, Sciubba DM, et al. Risk of infection following posterior instrumented lumbar fusion for degenerative spine disease in 817 consecutive cases. *J Neurosurg Spine*. 2014;20:45–52. doi:10.3171/2013.10.SPINE1364.
- [13] Maruo K, Berven SH. Outcome and treatment of postoperative spine surgical site infections: predictors of treatment success and failure. *J Orthop Sci*. 2014;19:398–404. doi:10.1007/s00776-014-0545-z.
- [14] Billières J, Uçkay I, Faundez A, Douissard J, Kuczma P, Suvà D, et al. Variables associated with remission in spinal surgical site infections. *J Spine Surg*. 2016;2:128–134. doi:10.21037/jss.2016.06.06.
- [15] Kowalski TJ, Berbari EF, Huddleston PM, Steckelberg JM, Osmon DR. Propionibacterium acnes vertebral osteomyelitis: seek and ye shall find? *Clin Orthop Relat Res*. 2007;461:25–30. doi:10.1097/BL0.0b013e318073c25d.

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QUESTION 3: Is there a role for chronic antibiotic suppression after treating patients with retained infected spinal hardware?

RECOMMENDATION: The use of chronic antibiotic suppression (CAS) has not been clearly investigated until now. However, it can be an option for patients whose implants cannot be removed or who refuse further surgeries because of comorbidities.

LEVEL OF EVIDENCE: Consensus

DELEGATE VOTE: Agree: 93%, Disagree: 0%, Abstain: 7% (Super Majority, Strong Consensus)

RATIONALE

Only one study has compared patients receiving CAS [1]. They found that 5 out of 22 patients with CAS had treatment failure, compared with 5 out of 6 in the control group. The definition they used for treatment failure was described as the need for an unanticipated debridement or a clinician's decision to give a second course of antibiotics. Suppressive antibiotics were given for a median time of 303 days (IQR 147 to 672) to patients with early onset infection and 410 days (IQR 61 to 667) to patients with late onset infection. Data on treatment failure was reported only for early onset infection patients. It could be argued that patients already under CAS would not have been eligible for a second course of antibiotic treatment and this could partly increase the rates of treatment failure on the group without CAS, biasing the study results.

Other studies reporting on antibiotic treatments show large variations in the duration of treatment. Miyazaki et al. reported a mean duration of oral treatment of 336 days, ranging from 89 to 1,673 days [2]. Their study focused on multi-resistant surgical site infection treated with implant retention. Maruo et al. reported an average duration of antibiotic treatment of 255.8 days with a standard deviation

of 283.4 days [3]. All these reports show a huge variation in the length of antibiotic treatment, with a select group of patients in each study receiving CAS. Decision for prolonged CAS was made at the clinician's discretion and based on the patient's symptoms, so there is no particular setting in which it would be possible to offer a sound recommendation. Besides the mentioned paper by Kowalski, there are no reports comparing CAS with other treatment regimes.

REFERENCES

- [1] Kowalski TJ, Berbari EF, Huddleston PM, Steckelberg JM, Mandrekar JN, Osmon DR. The management and outcome of spinal implant infections: contemporary retrospective cohort study. *Clin Infect Dis*. 2007;44(7):913–920.
- [2] Miyazaki S, Kakutani K, Maeno K, Takada T, Yurube T, Kurosaka M, Nishida K. Surgical debridement with retention of spinal instrumentation and long-term antimicrobial therapy for multidrug-resistant surgical site infections after spinal surgery: a case series. *Int Orthop*. 2016;40(6):1171–1177.
- [3] Maruo K, Berven SH. Outcome and treatment of postoperative spine surgical site infections: predictors of treatment success and failure. *J Orthop Sci*. 2014;19(3):398–404.

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