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Discussion #2:

Indications for medical intervention of primary osteodiskitis and epidural abscess

- Diagnosis
- Treatment considerations
- When to consider surgical consultation

Disclosures:

Alphatec spine consulting
Biomet spine consulting
DepuySynthes spine – travel expenses, speaking honorarium
Globus spine – travel expenses
Zimmer spine consulting

This presentation will not include product names, promote use of any company's products, or promote the off-label use of any drugs or devices

1. Diagnosis of osteomyelitis and epidural abscess

- Clinical presentation
- Laboratory markers
- Imaging studies

1. Diagnosis of osteomyelitis and epidural abscess

-Clinical presentation

Onset or exacerbation of neck or back pain
No relief with rest or analgesics
Pain often worse at night
Fever
New neurologic deficit
Cachexia

Tsiodras S, Falagas ME. Clinical assessment and medical treatment of spine infections. Clin Orthop Relat Res 2006;444:38e50.
Fantoni M, Trecarichi EM, Rossi B, Mazzotta V, Di Giacomo G, Nasto LA, Di Meco E, Pola E. Epidemiological and clinical features of pyogenic spondylodiskitis. Eur Rev Med Pharmacol Sci. 2012 Apr;16 Suppl 2:2-7.
Ziu M, Dengler B, Cordell D, Bartanusz V. Diagnosis and management of primary pyogenic spinal infections in intravenous recreational drug users. Neurosurg Focus. 2014 Aug;37(2):E3.

1. Diagnosis of osteomyelitis and epidural abscess

-Clinical presentation

Epidemiologic features:

Immunosuppression: HIV infection, chemotherapy, organ transplantation, chronic steroid use
Intravenous drug use
Advanced age
Diabetes mellitus
Chronic renal disease
Chronic liver disease
Malignancy
Prior trauma or surgery

Carragee EJ. Pyogenic vertebral osteomyelitis. J Bone Joint Surg Am 1997;79:874e80.
Fantoni M, Trecarichi EM, Rossi B, Mazzotta V, Di Giacomo G, Nasto LA, Di Meco E, Pola E. Epidemiological and clinical features of pyogenic spondylodiskitis. Eur Rev Med Pharmacol Sci. 2012 Apr;16 Suppl 2:2-7.
Ziu M, Dengler B, Cordell D, Bartanusz V. Diagnosis and management of primary pyogenic spinal infections in intravenous recreational drug users. Neurosurg Focus. 2014 Aug;37(2):E3.

Illustrative case – ‘Tony’

60 yo M, h/o DM and HTN. s/p MVA 4 months ago.

Presented to outside hospital with 3 months of thoracic back pain, chest pain and SOB

CT chest PE study obtained demonstrating bony destruction and surrounding mediastinal enhancement

Patient was transferred to University Hospital

1. Diagnosis of osteomyelitis and epidural abscess

-Laboratory Markers

✓ Peripheral WBC

✓ Sedimentation Rate

✓ C-Reactive Protein

✓ Procalcitonin

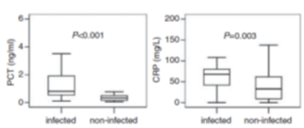
Poor sensitivity or specificity for epidural abscess or osteomyelitis
Elevated neutrophil count from peripheral smear more useful
Leukocytosis sensitivity 50% or less

ESR: High sensitivity for pyogenic infection
Level tends to remain high for prolonged period
Poor specificity – generalized marker of infection/inflammation

Acute phase reactant – faster response to clinical picture
Poor specificity
Liver production – dampened response with hepatic insufficiency

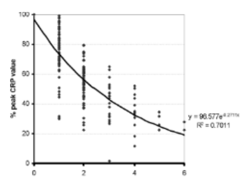
Acute upregulation in presence of infection
Not affected by noninfectious inflammatory processes (eg trauma, MI, recent surgery, DVT)
Highly sensitive and specific for infection

Black S, Kushner I, Samols D. C-reactive Protein. J Biol Chem 2004; 279: 48487–48490.
Takahashi J, Ebara S, Kamimura M, Kinoshita T, Itoh H, Yuzawa Y et al. Early-phase enhanced inflammatory reaction after spinal instrumentation surgery. Spine 2001; 26: 1698–1704.
Mok JM, Pekmezci M, Piper SL, Boyd E, Berven SH, Burch S, Deviren V, Tay B, Hu SS. Use of C-reactive protein after spinal surgery: comparison with erythrocyte sedimentation rate as predictor of early postoperative infectious complications. Spine (Phila Pa 1976). 2008 Feb 15;33(4):415-21.
Huang K, Du G, Wei C, Gu S, Tang J. Elevated serum lactoferrin and neopterin are associated with postoperative infectious complications in patients with acute traumatic spinal cord injury. Arch Med Sci. 2013 Oct 31;9(5):865-71.
Nie H, Jiang D, Ou Y, Quan Z, Hao J, Bai C, Huang X, An H. Procalcitonin as an early predictor of postoperative infectious complications in patients with acute traumatic spinal cord injury. Spinal Cord. 2011 Jun;49(6):715-20.
Hadjipavlou AG, Mader JT, Necessary JT, Muffoletto AJ. **Hematogenous pyogenic spinal infections and their surgical management.** Spine (Phila Pa 1976). 2000 Jul 1;25(13):1668-79.



Higher serum procalcitonin (PCT) levels (p<0.001) and C-reactive protein (p<0.01) seen in postop infection

From Nie et al



Normal postoperative CRP values and deterioration in patients without complication. Values represent decrease from postop peak CRP value (peak is variable and typically seen postop day 2-3).

From Mok et al

1. Diagnosis of osteomyelitis and epidural abscess

-Laboratory Markers

Greater elevation of WBC, ESR, CRP, and PRL seen in pyogenic compared to tuberculous osteomyelitis
Greater yield of blood cultures (40-50%) in pyogenic compared to tuberculous osteomyelitis (0-10%)

Spine (Phila Pa 1976). 2010 Oct 1;35(21):E1096-100. doi: 10.1097/BRS.0b013e3181e04dd3.
A comparative study of pyogenic and tuberculous spondylodiscitis.
Kim CJ1, Song KH, Jeon JH, Park WB, Park SW, Kim HB, Oh MD, Choe KW, Kim NJ.

1. Diagnosis of osteomyelitis and epidural abscess

-Radiology

MRI

MRI +/- gadolinium is gold standard for spinal canal imaging
MRI DWI sequence to distinguish abscess from other collection
Contrast enhancement of paraspinal collection can suggest abscess

CT

Helpful at demonstrating bony involvement/erosion
Not specific or sensitive

PET-CT

PET imaging not susceptible to metal artifact
Not specific to infection – increased uptake with inflammation
Less sensitive and specific than MRI for evaluation of infection

Radionuclide studies

Tagged WBC studies poorly specific due to WBCs in vertebral marrow
Tc99m uptake in osteoporosis, degenerative disease, and metastases in addition to infection

Riccio SA, Chu AK, Rabin HR, Kloiber R. Fluorodeoxyglucose Positron Emission Tomography/Computed Tomography Interpretation Criteria for Assessment of Antibiotic **Treatment** Response in Pyogenic **Spine** Infection. Can Assoc Radiol J. 2015 Jan 13.
Diehn FE. **Imaging of spine infection.** Radiol Clin North Am. 2012 Jul;50(4):777-98.
Radcliff KE, Morrison WB, Kepler C, Moore J, Sidhu G, Gendelberg D, Miller L, Sonagli M, Vaccaro AR. Distinguishing Pseudomeningocele, **Epidural** Hematoma, and Postoperative Infection on Postoperative MRI. J Spinal Disord Tech. 2013 Nov 5.
Moritani T, Kim J, Capizzano AA, Kirby P, Kademian J, Sato Y. **Pyogenic and non-pyogenic spinal infections: emphasis on diffusion-weighted imaging for the detection of abscesses and pus collections.** Br J Radiol. 2014 Sep;87(1041):20140011.
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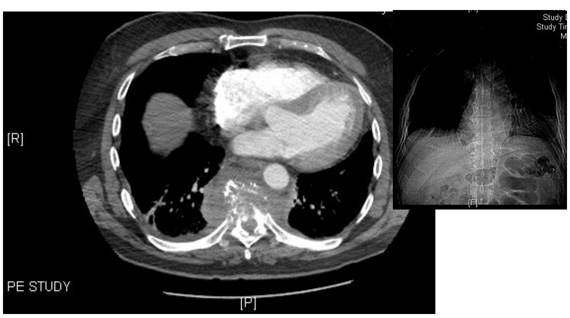
Thivolle P, Mathieu L, Mathieu P, Raynal M, Bouyoucef SE, Damideaux J, Vignon E, Berger M. **Significance of solitary spine abnormalities on technetium-99m bone imaging.** Clin Nucl Med. 1988 Jul;13(7):527-8.

Illustrative case – 'Tony'



Illustrative case – 'Tony'

CT looked suspicious for osteomyelitis, however only axial views present

PEx: AAOx3, Neurologically nonfocal exam
Mild SOB
Tender to palpation/percussion over thoracic spine
Afebrile

Blood cultures ordered (subsequently demonstrated no growth)

WBC	7.1
ESR	97
CRP	34
HIV	negative
Quantiferon gold	negative

Neurosurgery consulted – MRI Tspine +/- contrast recommended as well as TLSO brace

Illustrative case – ‘Tony’

MRI Tspine: T2 T1 T1 + gad

2. Antibiotic treatment factors

-Empiric abx – pro/con
-Isolation of organism
-Treatment duration

2. Antibiotic treatment factors

-Empiric abx – pro/con

Broad-spectrum coverage generally advocated until organism isolated
Immobilization of infected spinal column via bracing
Short term course of abx (<4 days) reported to not impact yield of biopsy
In some cases an organism is never isolated

Marschall J, Bhavan KP, Olsen MA, Fraser VJ, Wright NM, Warren DK. **The impact of prebiopsy antibiotics on pathogen recovery in hematogenous vertebral osteomyelitis.** Clin Infect Dis. 2011 Apr 1;52(7):867-72.
Pola E, Logroscino CA, Gentiempo M, Colangelo D, Mazzotta V, Di Meco E, Fantoni M. **Medical and surgical treatment of pyogenic spondylodiscitis.** Eur Rev Med Pharmacol Sci. 2012 Apr;16 Suppl 2:35-49.
Rankine JJ, Barron DA, Robinson P, Millner PA, Dickson RA. **Therapeutic impact of percutaneous spinal biopsy in spinal infection.** Postgrad Med J. 2004 Oct;80(948):607-9.

2. Antibiotic treatment factors

-Isolation of organism:

Yield of blood culture (20-50%)
Yield of percutaneous CT guided biopsy (53% Marschall; 32% Heyer; 72% Luzzatti; 48% Pupaibool)
Yield of surgical biopsy (91% Marschall; 92% Luzzatti)
60% concordance between blood culture result and biopsy result (Nanda)

Lower yield if TB is organism
Lower yield in diabetic patient
Greater yield if presence of paraspinal abscess
Greater yield if higher CRP value

Heyer CM, Brus LJ, Peters SA, Lemburg SP. **Efficacy of CT-guided biopsies of the spine in patients with spondylitis--an analysis of 164 procedures.** Eur J Radiol. 2012 Mar;81(3):e244-9.
Pupaibool J, Vasoo S, Erwin PJ, Murad MH, Berbari EF. The utility of image-guided percutaneous needle aspiration biopsy for the diagnosis of spontaneous **vertebral osteomyelitis**: a systematic review and meta-analysis. **Spine** J. 2015 Jan 1;15(1):122-31.
Gras G, Buzele R, Parienti JJ, Debiais F, Dinh A, Dupon M, Roblot F, Mulleman D, Marcelli C, Michon J, Bernard L. Microbiological diagnosis of **vertebral osteomyelitis**: relevance of second percutaneous biopsy following initial negative biopsy and limited yield of post-biopsy blood cultures. Eur J Clin Microbiol Infect Dis. 2014 Mar;33(3):371-5.
Marschall J, Bhavan KP, Olsen MA, Fraser VJ, Wright NM, Warren DK. **The impact of prebiopsy antibiotics on pathogen recovery in hematogenous vertebral osteomyelitis.** Clin Infect Dis. 2011 Apr 1;52(7):867-72.
Rankine JJ, Barron DA, Robinson P, Millner PA, Dickson RA. **Therapeutic impact of percutaneous spinal biopsy in spinal infection.** Postgrad Med J. 2004 Oct;80(948):607-9.
Kim CJ, Song KH, Park WB, Kim ES, Park SW, Kim HB, Oh MD, Kim NJ. Microbiologically and clinically diagnosed vertebral osteomyelitis: impact of prior antibiotic exposure. Antimicrob Agents Chemother. 2012 Apr;56(4):2122-4.
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Luzzati R, Giacomazzi D, Danzi MC, Tacconi L, Concia E, Vento S. Diagnosis, management and outcome of clinically- suspected spinal infection. J Infect. 2009 Apr;58(4):259-65.
Pupaibool J, Vasoo S, Erwin PJ, Murad MH, Berbari EF. **The utility of image-guided percutaneous needle aspiration biopsy for the diagnosis of spontaneous vertebral osteomyelitis: a systematic review and meta-analysis.** Spine J. 2015 Jan 1;15(1):122-31.

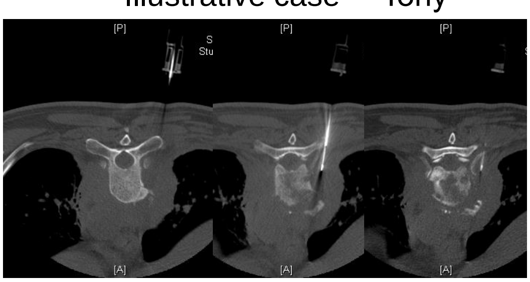
Illustrative case – ‘Tony’

MRI Tspine interpreted as consistent with osteomyelitis at T8-9

Minimal kyphosis
Minimal canal stenosis

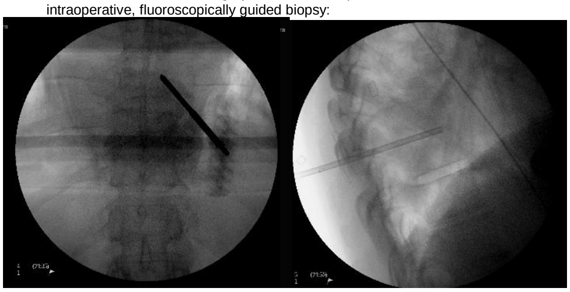
Infectious Disease consulted
TLSO brace ordered
Interventional Radiology consulted for CT guided biopsy of T8-9 disk

Illustrative case – ‘Tony’



Illustrative case – 'Tony'

Following failure of CT guided biopsy to identify an organism, in the rib head or otherwise, neurosurgery is consulted to perform an intraoperative, fluoroscopically guided biopsy:



2. Antibiotic treatment factors

-Treatment duration:

Standardized duration (6 weeks)
vs
Serial monitoring of serologies (Yoon et al and Bettini et al, below):
followup ESR, CRP for appropriate response at 4 weeks (ESR >55 and CRP > 2.75 corresponded with treatment failure); treatment duration based on lab value responses to treatment

Yoon SH, Chung SK, Kim KJ, Kim HJ, Jin YJ, Kim HB. **Pyogenic vertebral osteomyelitis: identification of microorganism and laboratory markers used to predict clinical outcome.** Eur Spine J. 2010 Apr;19(4):575-82. doi: 10.1007/s00586-009-1216-1.
Bettini N, Girardo M, Dema E, Cervellati S. **Evaluation of conservative treatment of non specific spondylodiscitis.** Eur Spine J. 2009 Jun;18 Suppl 1:143-50.
Connor DE Jr, Chittiboina P, Caldito G, Nanda A. **Comparison of operative and nonoperative management of spinal epidural abscess: a retrospective review of clinical and laboratory predictors of neurological outcome.** J Neurosurg Spine. 2013 Jul;19(1):119-27.
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Bernard L, Dinh A, Ghout I, Simo D, Zeller V, Issartel B, Le Moing V, Belmatoug N, Lesprit P, Bru JP, Therby A, Bouhour D, Dénes E, Debard A, Chirouze C, Fèvre K, Dupon M, Aegerter P, Mulleman D; on behalf of the Duration of **Treatment** for Spondylodiscitis (DTS) study group. Antibiotic **treatment** for 6 weeks versus 12 weeks in patients with pyogenic **vertebral osteomyelitis**: an open-label, non-inferiority, randomised, controlled trial. Lancet. 2014 Nov 5.

2. Antibiotic treatment factors

Treatment failure/recurrence:

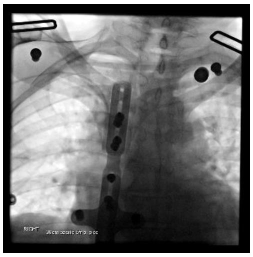
Most treatment failure seen within 2 years; average under 5 months
Most failure seen with S. aureus as organism and greater duration of infection prior to treatment
Treatment failure more likely with shorter duration of antibiotic therapy
Failure LESS likely in osteomyelitis cases with no isolated organism
75% rate of failure of medical treatment of cervical epidural abscess due to neurologic deterioration (Alton)
Greater likelihood of treatment failure with tuberculous osteomyelitis due to deformity and/or neurologic deficit (Colmenero)

Gupta A, Kowalski TJ, Osmon DR, Enzler M, Steckelberg JM, Huddleston PM, Nassr A, Mandrekar JM, Berbari EF. **Long-term outcome of pyogenic vertebral osteomyelitis: a cohort study of 260 patients.** Open Forum Infect Dis. 2014 Dec 5;1(3):ofu107.
Kim J, Kim YS, Peck KR, Kim ES, Cho SY, Ha YE, Kang CI, Chung DR, Song JH. **Outcome of culture-negative pyogenic vertebral osteomyelitis: comparison with microbiologically confirmed pyogenic vertebral osteomyelitis.** Semin Arthritis Rheum. 2014 Oct;44(2):246-52.
Alton TB, Patel AR, Bransford RJ, Bellabarba C, Lee MJ, Chapman JR. Is there a difference in neurologic outcome in medical versus early operative management of cervical epidural abscesses? **Spine** J. 2015 Jan 1;15(1):10-7
Colmenero JD, Jiménez-Mejías ME, Sánchez-Lora FJ, Reguera JM, Palomino-Nicás J, Martos F, García de las Heras J, Pachón J. Pyogenic, tuberculous, and **brucellar** vertebral osteomyelitis: a descriptive and comparative study of 219 cases. Ann Rheum Dis. 1997 Dec;56(12):709-15.

Illustrative case – 'Tony'

Intraoperative biopsy is positive for Streptococcus group G

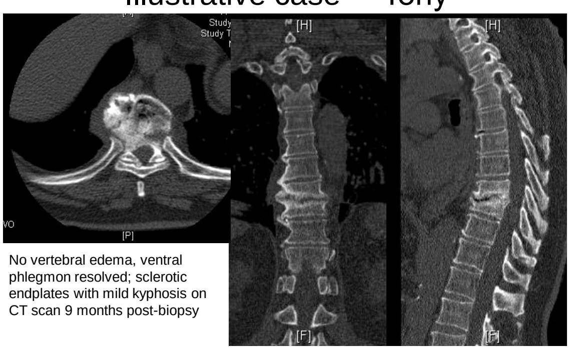
Patient is started on IV vancomycin and Zosyn once biopsy obtained and PICC line is placed; subsequently abx changed to IV ertepenem



Do note the TLSO brace the patient is wearing

	wbc	esr	crp
2 weeks of treatment	5.4	81	14
4 weeks of treatment	6.1	54	5
IV abx stopped at 5 weeks, changed to PO keflex			
6 weeks of treatment	5.6	57	6
Resume IV ertepenem			
8 weeks of treatment	4.9	52	4
10 weeks of treatment	5.3	21	3
IV abx stopped			
14 weeks of treatment	5.6	13	3

Illustrative case – 'Tony'



No vertebral edema, ventral phlegmon resolved; sclerotic endplates with mild kyphosis on CT scan 9 months post-biopsy

3. When to consider surgical referral

Development of spinal deformity
Onset of neurologic deficit
Failure to identify organism via CT-guided biopsy
Infection recalcitrant to medical therapy

Patel AR, Alton TB, Bransford RJ, Lee MJ, Bellabarba CB, Chapman JR. Spinal epidural abscesses: **risk factors**, medical versus surgical management, a retrospective review of 128 cases. **Spine** J. 2014 Feb 1;14(2):326-30
Srinivasan D, Terman SW, Himedan M, Dugo D, La Marca F, Park P **Risk factors** for the development of deformity in patients with spinal infection. Neurosurg Focus. 2014 Aug;37(2):E2
Alton TB, Patel AR, Bransford RJ, Bellabarba C, Lee MJ, Chapman JR. Is there a difference in neurologic outcome in medical versus early operative management of cervical epidural abscesses? **Spine** J. 2015 Jan 1;15(1):10-7.
Arnold R, Rock C, Croft L, Gilliam BL, Morgan DJ. **Factors** associated with treatment failure in vertebral **osteomyelitis** requiring spinal instrumentation. Antimicrob Agents Chemother. 2014;58(2):880-4.
Srinivasan D, Terman SW, Himedan M, Dugo D, La Marca F, Park P Risk factors for the development of deformity in patients with spinal infection. Neurosurg Focus. 2014 Aug;37(2):E2
Ghobrial GM, Beygi S, Viereck MJ, Maulucci CM, Sharan A, Heller J, Jallo J, Prasad S, Harrop JS. Timing in the **surgical** evacuation of spinal **epidural** abscesses. Neurosurg Focus. 2014 Aug;37(2):E1.
Bydon M, De la Garza-Ramos R, Macki M, Naumann M, Sciubba DM, Wolinsky JP, Bydon A, Gokaslan ZL, Witham TF. Spinal instrumentation in patients with primary spinal infections does not lead to greater recurrent infection rates: an analysis of 118 cases. World Neurosurg. 2014 Dec;82(6):e807-14.
Connor DE Jr, Chittiboina P, Caldito G, Nanda A. **Comparison of operative and nonoperative management of spinal epidural abscess: a retrospective review of clinical and laboratory predictors of neurological outcome.** J Neurosurg Spine. 2013 Jul;19(1):119-27.
Hadjipavlou AG, Mader JT, Necessary JT, Muffoletto AJ. **Hematogenous pyogenic spinal infections and their surgical management.** Spine (Phila Pa 1976). 2000 Jul 1;25(13):1668-79.
Gasbarrini AL, Bertoldi E, Mazzetti M, Fini L, Terzi S, Gonella F, Mirabile L, Barbanti Bròdano G, Furno A, Gasbarrini A, Boriani S. Clinical features, diagnostic and therapeutic approaches to haematogenous vertebral osteomyelitis. Eur Rev Med Pharmacol Sci. 2005 Jan-Feb;9(1):53-66.

- Thank you!

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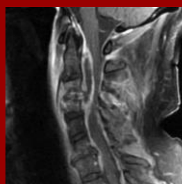
Indications and Techniques for Surgical Intervention for Primary Vertebral Osteomyelitis/Discitis (PVO)



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Disclosures

- Depuy Spine
  - Consultant and research support
- Medtronic
  - Consultant

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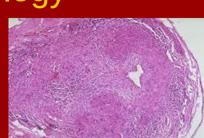
Pathophysiology

- PVO can lead to:
  - Epidural abscess
  - Spinal instability
  - Sepsis
- Spinal Cord/Nerve Compression
- Vascular compromise
  - Arteritis
  - Thrombophlebitis



Diagnostic Work-Up

- Clinical suspicion
- Laboratory
  - CBC with differential
  - ESR
  - CRP
  - Blood Cultures (~50-60%)
- Imaging
  - MRI
  - CT with contrast
- Biopsy
- Lumbar puncture?

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Treatment

- Timely treatment impacts outcome
  - Sepsis
  - Paralysis
  - Death
- The mortality of SEA dropped from 34% in the period of 1954-1960 to 15% in 1991-1997 (Reihsaus et al; Spinal epidural abscess: a meta-analysis of 915 patients)

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Treatment

- Medical treatment
  - Culture based antibiotics Rx
  - Empiric antibiotics Rx
  - ID consult
  - Neurosurgery/neurology consult
  - Serial neuro monitoring
  - Favorable factors
    - Neurological intact patient
    - Lumbar or sacral disease
    - Minimal spinal canal compromise
    - Age
    - Trending CBC/ESR/CRP/fever
  - Optimize volume status and BP

"Your infection may be antibiotic-resistant, but let's see how it responds to intensive litigation."

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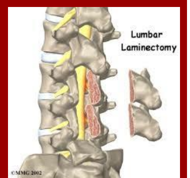
Surgical Treatment



- Surgical treatment indications
  - Neurological deficits
  - Failed medical treatment
  - Spinal instability
  - Post-infectious deformity
- Timing
  - Emergent/urgent versus Delayed
  - Neurological status
  - Location of abscess
  - Degree of spinal canal compromise

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Goals of Surgical Treatment of PVO

- Neural decompression
- Confirm tissue diagnosis
- Debridement of devitalized bone and tissues
- Spinal stabilization when indicated

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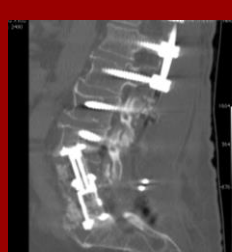
- Surgical options
  - Decompression only
    - Laminectomy
  - Decompression and stabilization
    - Anterior
    - Posterior



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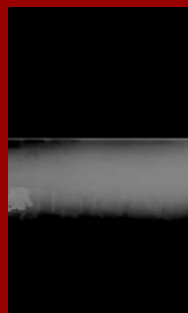
Surgery Options

- Posterior approach
  - Laminectomy
  - Laminectomy and fusion
- Anterior approach
  - Corpectomy and fusion
- Anterior and posterior approaches
  - Posterolateral corpectomy and PSF



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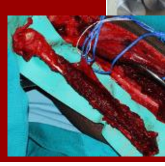
Surgical Consideration

- Minimize foreign bodies/non-vascularized
  - PEEK implant?
- Implant selection
  - Titanium Vs. Stainless Steel
- Graft selection
  - Autograft
  - Vascularized graft
  - rhBMP-2
- Tissue management
  - Obliterate dead space
  - Vascularized tissues



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Summary

- Vertebral osteomyelitis/discitis with spinal epidural disease is associated with high morbidity/mortality rate
- Early diagnosis and treatment is paramount
- Antibiotics therapy is mainstay therapy
- Surgery indicated in progressive neurological deficits, failure of medical treatment, post-infectious instability or deformity.

Treatment of postoperative infection

Nader Dahdaleh, MD
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Conflict of Interest

- None

Postoperative infection

Early: weeks
Delayed: months

Superficial
Deep

Non instrumented
Instrumented

Postoperative infection

Early: weeks
Delayed: months

Superficial → Wound care and antibiotics
Deep

Non instrumented
Instrumented

Postoperative infection

Early: weeks
Delayed: months

Superficial
Deep → Surgical debridement and antibiotics

Non instrumented
Instrumented

Postoperative infection

Early: weeks
Delayed: months

Superficial
Deep

Non instrumented
Instrumented

Risk factors

Patient factors:
- Advanced age
- Malnutrition
- Immunocompromised

Intra-operative factors:
- Length of surgery
- Number of levels
- Posterior surgical approach
- Open surgery
- Use of intra-operative equipment: microscopes, O-arm or C-arm

Timing

- Early: Staphylococcus aureus and beta-hemolytic Streptococcus
- Delayed: less virulent pathogens, most commonly Propionibacterium acnes

Management of deep wound postoperative infections in the presence of hardware

- Retaining versus removing the hardware
- Duration of antibiotics

Studies assessing instrumentation retention versus removal in the setting of deep post-operative infection

Authors (year)[a]	Patients[b] (early/delayed infection)	Surgical management at time of infection	Mean no. of surgeries to eradicate infection	Findings
Glassman et al. (1996) [17]	19 (not reported)	Serial debridements until OR cultures negative then delayed primary closure	4.2	Instrumentation retained successfully in 19/19 patients with aggressive serial debridements and IV antibiotics
Viola et al. (1997) [21]	8 (0/8)	Debridement and instrumentation removal	1	100% eradication of infection with instrumentation removal for delayed infection. 3/8 required delayed reinstrumentation for progressive deformity
Szoke et al. (1998) [10]	15 (14/1)	Debridement and primary closure with retention of instrumentation	Not reported	Instrumentation retention successful with early infection after debridement and IV antibiotics (14/14). Delayed infection required instrumentation removal for recurrent infection (1/1)
Clark et al. (1999) [26]	22 (0/22)	Debridement, removal of instrumentation and primary closure	Not reported	Infection cleared in all patients after instrumentation removal. 4/22 scoliosis patients had pseudoarthrosis/loss of correction after instrumentation removal, three of whom underwent subsequent re-instrumentation
Aydinli et al. (1999) [8]	11 (0/11)	Washout and retention of instrumentation	Not reported	Infection recurred in all patients following instrumentation retention, requiring removal within 5 years of index surgery, however all patients went on to develop stable union prior to removal
Picada et al. (2000) [25]	26 (16/10)	Serial debridements, instrumentation retention and secondary closure	Not reported	24/26 patients successfully cleared infection with serial debridements and antibiotics without instrumentation removal
Sponseller et al. (2000) [30]	25 (not reported)	Debridement and secondary intention with retention of instrumentation	Not reported	Instrumentation retained successfully in 18/25 (11 with single debridement, seven with multiple). Early versus delayed not reported. 7/25 required instrumentation removal for recurrent infection
Richards et al. (2001) [27]	23 (0/23)	Debridement and removal of instrumentation at first stage	1.4	Instrumentation removal successful for eradication of delayed infection (23/23). For pseudoarthrosis (3/23), delayed re-instrumentation was tolerated and did not cause reinfection
Hahn et al. (2005) [16]	7 (0/7)	Debridement and instrumentation removal	1	Instrumentation removal successful for eradication of infection, but observed 10–28° loss of correction in 3/8 scoliosis patients
Collins et al. (2008) [1]	74 (9/65)	Debridement and removal of instrumentation if solid fusion observed	Not reported	Only 46% of scoliosis patients had stable pain-free spines after debridement and instrumentation removal. Only one patient required delayed reinstrumentation for loss of correction
Potter et al. (2006) [20]	6 (0/6)	Debridement and instrumentation removal	1	Instrumentation removal in patients with adolescent idiopathic scoliosis associated with mean loss of 10° of coronal correction
Kowalski et al. (2007) [24]	81 (30/51)	Variable	Not reported	Instrumentation retention successful for early infection (77% 2 year infection-free survival). For delayed infection, instrumentation removal associated with higher 2 year infection-free survival compared to retention
Mirovsky et al. (2007) [22]	8 (not reported)	Debridement and instrumentation retention	Not reported	Instrumentation successfully retained in all eight patients with 100% infection eradication
Ho et al. (2007) [28]	53 (31/22)	Variable	1.6	50% rate of recurrent infection when instrumentation retained, compared to 20% with removal. Following instrumentation removal in deformity patients, 6/10 patients developed >10° loss of correction
Hedequist et al. (2009) [29]	26 (0/26)	Debridement and instrumentation retention	4	Instrumentation retention was unsuccessful for delayed infection. All 26 patients had recurrent infection requiring removal. Hospital costs were lower with early instrumentation removal. Six patients required subsequent reinstrumentation for deformity progression
Riha et al. (2008) [9]	7 (1/6)	Hardware removed for delayed infection. Retained for early infection	2	All delayed infections resolved with a single debridement and hardware removal. Instrumentation retention failed for acute infection, requiring five debridements, removal, and reimplantation
Cahill et al. (2010) [7]	81 (32/29)	Variable	2	Higher rate of reoperation in patients who underwent instrumentation removal compared to retention. Average 23° of deformity progression after instrumentation removal compared to only 2° with retention
Pull ter Gunne et al. (2010) [12]	84 (not reported)	Debridement, instrumentation removal and primary closure	1.3	76% of patients with deep surgical site infection were able to clear infection with single debridement and instrumentation retention
Ahmed et al. (2012) [16]	16 (not reported)	Debridement and instrumentation retention	Not reported	Instrumentation retention successful in all 16 patients, with 100% eradication of infection at 2 year follow-up
Maruo et al. (2014) [15]	166 (not reported)	Instrumentation retention for 76%, removal for 24%	1.4	79% rate of early resolution of infection with implant retention, this is equal to the rate of early resolution with instrumentation removal. Authors favor retention for early infection

IV = intravenous, no. = number, OR = operating room.
[a] All studies were retrospective and the quality of the evidence is level III.
[b] Number of patients with deep post-operative infection in the setting of instrumentation. Early infection <90 days after index surgery.

Lall RR, J clin neurosc, 2015

Studies addressing duration of antibiotic therapy

Authors (year)[a]	No. of patients[b] (early/delayed infection)	Duration of postoperative antibiotics (mean)	Findings
Clark et al. (1999) [26]	22 (0/22)	48–72 hours IV + 7 days oral	For delayed infection, short course of IV therapy followed by 1 week oral therapy is adequate after instrumentation removal (100% infection eradication)
Kowalski et al. (2007) [24]	81 (30/51)	Varied	If instrumentation retained, 6 weeks of IV therapy followed by 6 months of oral suppressive therapy associated with higher rate of infection control (22% treatment failure) than IV therapy alone (83% treatment failure)
Riha et al. (2008) [9]	7 (1/6)	6 weeks IV only	6 weeks of IV therapy adequate for treatment of delayed infection (6/6 without recurrence). Acute infection required longer course (8 weeks IV followed by 8 weeks oral) for successful eradication
Collins et al. (2008) [1]	74 (9/65)	4 weeks IV followed by 5 weeks oral	Prolonged IV therapy followed by suppressive oral regimen was inadequate if instrumentation retained (40% recurrence), but adequate if instrumentation removed (0% recurrence)

IV = intravenous, No. = number.
[a] All studies were retrospective and the quality of the evidence is level III.
[b] Number of patients with post-operative infection in the setting of instrumentation. Early infection <90 days after index surgery.

Lall RR, J clin neurosc, 2015

Case 1

- 70 year old man
- Metastatic lung Ca: diagnosed 2005
- L5 metastases: s/p chemo and Rx Therapy X2

Presented 4 weeks post op:

Confusion, draining wound
Fever, SBP: 90
WBC: 22,000
CRP 25
ESR >120

Blood cultures: E coli and Proteus Vulgaris

Wound washout: emergent
+ broad spectrum antibiotics
Wound cultures: same as blood cultures

Post op: CRP dropped then increased over the next few days

2nd wound washout: broad spectrum antibiotics, discharged

Presented with draining wound, increasing crp 10 days later
3rd wound washout and replacing hardware

18 month follow up:

Wound healed
Suppressive antibiotic treatment:
Ciprofloxacin

Case 2

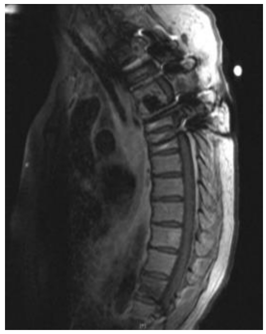
- 73 year old female
- Metastatic melanoma
- Mid thoracic pain, Neurologically normal → T5 metastases

Presented 4 weeks later with draining wound

No fevers
Nl WBC count
Nl CRP

Wound washout → hardware retained

4 weeks oxacillin
4 weeks cephalexin



Case 3

- 25 yo female with history of adolescent idiopathic scoliosis s/p selective thoracic fusion
- She presented to the ED with right sided paraspinal pain and bump, s/p aspiration at an outside hospital

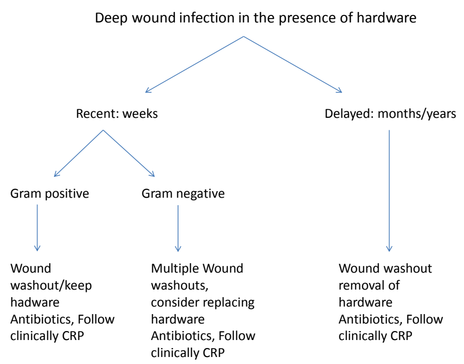
Taken for wound exploration and washout

Intraoperative purulent material involving the hardware on both sides

Stainless steel hardware removal

Cultures: P. Acnes

Anbiotics: vancomycin then Meropenem X 12 weeks


Deep wound infection in the presence of hardware
Recent: weeks
Delayed: months/years
Gram positive
Gram negative
Wound washout/keep hadware Antibiotics, Follow clinically CRP
Multiple Wound washouts, consider replacing hardware Antibiotics, Follow clinically CRP
Wound washout removal of hardware Antibiotics, Follow clinically CRP

Prevention and Cost of Post-Operative Infection

VuMedi LSRS Presents: Infections in Spine Surgery Webinar

Daniel S. Yanni, MD
Director, Comprehensive Spine Neurosurgery Service
March 31st, 2015

UC Irvine Health

Rates of Post-Operative Infection

- Rates of spinal SSI range from 1-12%
  - Surgery type, duration, and risk factors influence (Beiner, 2003)
- Bone grafts and instrumentation increase risk of SSI
  - Implantation of foreign bodies
- Revisions have a higher rate of SSI (up to 12%) (Radcliff, 2015)
- MIS may have lower rate of SSI
- Medical comorbidities WILL increase rates of SSI considerably
- Time of day procedure performed can also influence
  - Surgery performed later in the day have been found to carry higher risk of SSI (Gruskay, 2012)

Beiner, J. M., Grauer, J., Kwon, B. K. & Vaccaro, A. R. Postoperative wound infections of the spine. *Neurosurg Focus* **15**, E14 (2003).

Gruskay, J., Kepler, C., Smith, J., Radcliff, K. & Vaccaro, A. Is surgical case order associated with increased infection rate after spine surgery? *Spine* **37**, 1170-1174, doi:10.1097/BRS.0b013e3182407859 (2012).

Radcliff, K. E. *et al*. What is new in the diagnosis and prevention of spine surgical site infections. *The spine journal : official journal of the North American Spine Society* **15**, 336-347, doi:10.1016/j.spinee.2014.09.022 (2015).

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Surgical Infections

MIS Groups carry Decreased risk of surgical infections

- O'Toole et al. retrospective review of 1338 MIS procedures
  - Simple decompression SSI 0.10%
  - **Fusion SSI 0.74%**
  - Composite for all MIS procedures 0.22%
- Historically, open procedures SSI 2-6%
  - Decompression < 1%
  - **Fusion > 10%**

SSI = surgical site infection

O'Toole JE, Eichholz KM, Fessler RG. Surgical site infection rates after minimally invasive spinal surgery. J Neurosurg Spine. 2009 Oct;11(4):471-6.

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Prevention: Patient Selection and Modifiable Risk Factors

- Consider conservative/non-operative management
  - multiple medical comorbidities, osteoporosis, and advanced age should be managed medically or OPTIMIZE prior to surgical intervention
- Obese patients should be encouraged to reduce **BMI <30** prior to surgery (De la Garza-Ramos, 2015)
  - Significantly higher risk of post-op complications with elevated BMI
- Smoking cessation interventions for 1-2 months minimum before surgery can reduce risk of SSI (Thomsen, 2009)
- Strict pre- and post-operative control of serum **glucose** levels
  - <125 mg/dL pre-op and <200mg/dL postop can reduce post-op SSI (Olsen, 2008)

De la Garza-Ramos, R. *et al.* The impact of obesity on short- and long-term outcomes after lumbar fusion. *Spine* **40**, 56-61, doi:10.1097/brs.0000000000000655 (2015).

Olsen, M. A. *et al.* Risk factors for surgical site infection following orthopaedic spinal operations. *The Journal of bone and joint surgery. American volume* **90**, 62-69, doi:10.2106/jbjs.f.01515 (2008).

Thomsen, T., Tonnesen, H. & Moller, A. M. Effect of preoperative smoking cessation interventions on postoperative complications and smoking cessation. *The British journal of surgery* **96**, 451-461, doi:10.1002/bjs.6591 (2009).

Prevention: Preoperative Reduction of Bacterial Colonization

- **Bathe** preoperatively with Chlorhexidine gluconate (4%)
  - reduce postoperative spinal infections (Epstein, 2011)
- Screening and decolonization of known nasal carriers of S. aureus
  - Also can reduce risk of SSI (Bode, 2010)

Bode, L. G. *et al.* Preventing surgical-site infections in nasal carriers of Staphylococcus aureus. *The New England journal of medicine* **362**, 9-17, doi:10.1056/NEJMoa0808939 (2010).

Epstein, N. E. Preoperative, intraoperative, and postoperative measures to further reduce spinal infections. *Surgical neurology international* **2**, 17, doi:10.4103/2152-7806.76938 (2011).

Prevention: OR Prep of the Surgical Site

- Significant variability in surgeon practices of preoperative skin preparation in spine surgery
- Chlorhexidine appears to be more effective than povidone-iodine alone at reducing SSI (Al Maqbali, 2013)
- Preoperative antiseptic skin preparation using chlorhexidine followed by povidone-iodine has been shown to reduce SSI in neurosurgical procedures (Guzel, 2009)
- Thorough, sterile antiseptic skin preparation by a **trained provider** is critical in reducing SSI

Al Maqbali, M. A. Preoperative antiseptic skin preparations and reducing SSI. *British journal of nursing (Mark Allen Publishing)* **22**, 1227-1233, doi:10.12968/bjon.2013.22.21.1227 (2013).

Guzel, A. *et al.* Evaluation of the skin flora after chlorhexidine and povidone-iodine preparation in neurosurgical practice. *Surgical neurology* **71**, 207-210; discussion 210, doi:10.1016/j.surneu.2007.10.026 (2009).

Prevention: Intraoperative Contamination

- Time in-room prior to procedure (>1hr) has been shown to increase SSI in spine surgery (Radcliff, 2013)
- Insufficient intraoperative irrigation of the wound has been shown to be a risk factor for spinal SSI (Watanabe, 2010)
- Many surgeons opt to use antibiotic-impregnated (Bacitracin) saline irrigation to reduce intraoperative bacterial growth,
  - reduction of SSIs is not clear (Savitz, 1998; Barnes, 2014)

Barnes, S., Spencer, M., Graham, D. & Johnson, H. B. Surgical wound irrigation: a call for evidence-based standardization of practice. *American journal of infection control* **42**, 525-529, doi:10.1016/j.ajic.2014.01.012 (2014).

Radcliff, K. E. *et al.* Preoperative delay of more than 1 hour increases the risk of surgical site infection. *Spine* **38**, 1318-1323, doi:10.1097/BRS.0b013e31828f1f0b (2013).

Savitz, S. I., Savitz, M. H., Goldstein, H. B., Mouracade, C. T. & Malangone, S. Topical irrigation with polymyxin and bacitracin for spinal surgery. *Surgical neurology* **50**, 208-212 (1998).

Watanabe, M. *et al.* Risk factors for surgical site infection following spine surgery: efficacy of intraoperative saline irrigation. *Journal of neurosurgery. Spine* **12**, 540-546, doi:10.3171/2009.11.spine09308 (2010).

Paraspinal Muscle Injury and Infection

MIS vs Open

Paraspinal Muscle Ischemia and Infection

- Stevens et al. compared intramuscular pressure generated by open vs MIS retractors
  - Cadaveric model showed 3 x higher pressure in open retractors vs MIS
    - Tissue perfusion pressure = retractor pressure – MAP
    - Open retractors can give a zero tissue perfusion pressure
  - Recommend taking down retractors and irrigating periodically during lengthy procedures
  - Correlated on post-op MRI with significant increase in T2 and ADC measurements
    - Attributed to edema associated with denervation and ischemia

*ADC = apparent diffusion coefficient

•Stevens KJ, Spenciner DB, Griffiths KL, Kim KD, Zwienenberg-Lee M, Alamin T, Bammer R. Comparison of minimally invasive and conventional open posterolateral lumbar fusion using magnetic resonance imaging and retraction pressure studies. J Spinal Disord Tech. 2006 Apr;19(2):77-86.

Prevention: Intraoperative Local Application of Antibiotics

- Vancomycin powder is an easy, safe and inexpensive option for reduction of SSIs in spine surgery
- Multiple studies and meta-analyses have demonstrated reduction in spinal SSI with use of vancomycin powder
- Greater benefit in instrumented spine cases (Khan, 2014)
- Some reports of sterile seromas with use of vancomycin powder

Bakhsheshian, J., Dahdaleh, N. S., Lam, S. K., Savage, J. W. & Smith, Z. A. The Use of Vancomycin Powder In Modern Spine Surgery: Systematic Review and Meta-Analysis of the Clinical Evidence. *World neurosurgery*, doi:10.1016/j.wneu.2014.12.033 (2014).

Khan, N. R. *et al.* A meta-analysis of spinal surgical site infection and vancomycin powder. *Journal of neurosurgery. Spine* **21**, 974-983, doi:10.3171/2014.8.spine1445 (2014).

Prevention: Postoperative Antibiotic Prophylaxis

- Antibiotic prophylaxis has been demonstrated to reduce spinal SSI by 63% (Barker 2002)
- NASS recommends prophylactic antibiotics for instrumented and non-instrumented spine surgery
- JCAHO recommends Administration of IV antibiotics within 1 hour of incision
- **Increase** the antibiotic dosage to adjust for obesity

Barker, F. G., 2nd. Efficacy of prophylactic antibiotic therapy in spinal surgery: a meta-analysis. *Neurosurgery* **51**, 391-400; discussion 400-391 (2002).

Olsen, M. A. *et al.* Risk factors for surgical site infection following orthopaedic spinal operations. *The Journal of bone and joint surgery. American volume* **90**, 62-69, doi:10.2106/jbjs.f.01515 (2008).

Savage, J. W. & Anderson, P. A. An update on modifiable factors to reduce the risk of surgical site infections. *The spine journal : official journal of the North American Spine Society* **13**, 1017-1029, doi:10.1016/j.spinee.2013.03.051 (2013).

Prevention: Closed-Suction Drains and Suture

- Closed-suction drains have not been shown to have a significant affect on spinal fusion SSIs (Scuderi, 2005; Diab, 2012)
- Some studies suggest antibacterial-coated sutures reduce the adherence of bacteria to the suture and may decrease the rate of SSI (Edmiston, 2006)
- Antibiotic coated suture may reduce SSI when compared to non-treated suture (Ueno, 2013)

Diab, M. *et al.* Use and outcomes of wound drain in spinal fusion for adolescent idiopathic scoliosis. *Spine* **37**, 966-973, doi:10.1097/BRS.0b013e31823bbf0b (2012).

Edmiston, C. E. *et al.* Bacterial adherence to surgical sutures: can antibacterial-coated sutures reduce the risk of microbial contamination? *Journal of the American College of Surgeons* **203**, 481-489, doi:10.1016/j.jamcollsurg.2006.06.026 (2006).

Scuderi, G. J., Brusovanik, G. V., Fitzhenry, L. N. & Vaccaro, A. R. Is wound drainage necessary after lumbar spinal fusion surgery? *Medical science monitor : international medical journal of experimental and clinical research* **11**, Cr64-66 (2005).

Ueno, M. *et al.* Triclosan-coated sutures reduce wound infections after spinal surgery: a retrospective, nonrandomized, clinical study. *The spine journal : official journal of the North American Spine Society*, doi:10.1016/j.spinee.2013.06.046 (2013).

Prevention: Dressing

- A Cochrane review found no particular wound dressing is more effective than others in reducing the rates of SSI
- Silver-impregnated dressings may decrease rates of SSI in lumbar fusions (Epstein, 2007)
  - may be preferable for patients with moderate to high risk of infection (Leaper, 2010)

Dumville, J. C., Gray, T. A., Walter, C. J., Sharp, C. A. & Page, T. Dressings for the prevention of surgical site infection. *The Cochrane database of systematic reviews* **9**, Cd003091, doi:10.1002/14651858.CD003091.pub3 (2014).

Epstein, N. E. Do silver-impregnated dressings limit infections after lumbar laminectomy with instrumented fusion? *Surgical neurology* **68**, 483-485; discussion 485, doi:10.1016/j.surneu.2007.05.045 (2007).

Leaper, D., Nazir, J., Roberts, C. & Searle, R. Economic and clinical contributions of an antimicrobial barrier dressing: a strategy for the reduction of surgical site infections. *Journal of medical economics* **13**, 447-452, doi:10.3111/13696998.2010.502077 (2010).

Cost: Healthcare System Costs

- Nearly 1 million SSIs happen in the US every year, with an estimated total cost of $1.6 billion (Zhan, 2003)
- Direct health care cost of spinal SSI cervical and lumbar fusions ranges from $4,067 - $17,552 per infection
  - Can increase significantly when hardware affected
- More study is needed in this area to assess the costs of SSI in spinal surgery

Kuhns, B. D. *et al.* Cost and quality of life outcome analysis of postoperative infections after subaxial dorsal cervical fusions. *Journal of neurosurgery. Spine*, 1-6, doi:10.3171/2014.10.spine14228 (2015)

McGirt, M. J. *et al.* Comparative analysis of perioperative surgical site infection after minimally invasive versus open posterior/transforaminal lumbar interbody fusion: analysis of hospital billing and discharge data from 5170 patients. *Journal of neurosurgery. Spine* **14**, 771-778, doi:10.3171/2011.1.spine10571 (2011).

Whitmore, R. G. *et al.* Patient comorbidities and complications after spinal surgery: a societal-based cost analysis. *Spine* **37**, 1065-1071, doi:10.1097/BRS.0b013e31823da22d (2012).

Zhan, C. & Miller, M. R. Excess length of stay, charges, and mortality attributable to medical injuries during hospitalization. *Jama* **290**, 1868-1874, doi:10.1001/jama.290.14.1868 (2003).

Cost: Patient Costs

- Average 23 additional missed workdays for patients with dorsal cervical SSIs
  - approximately $3739 more in lost income (Kuhns, 2015)
- Medicaid patients have higher risk of SSI
  - higher associated cost
  - with a concurrent reduction in reimbursement following passage of the ACA (Manoso, 2014)

Kuhns, B. D. *et al.* Cost and quality of life outcome analysis of postoperative infections after subaxial dorsal cervical fusions. *Journal of neurosurgery. Spine*, 1-6, doi:10.3171/2014.10.spine14228 (2015)

Manoso, M. W. *et al.* Medicaid status is associated with higher surgical site infection rates after spine surgery. *Spine* **39**, 1707-1713, doi:10.1097/brs.0000000000000496 (2014).

Key Points

- Appropriate patient selection and counseling reduces risk of SSI
- Reduction in bacterial colonization of skin and nares is a prevention strategy
- Copious irrigation and use of local and systemic perioperative antibiotic prophylaxis reduces SSI rate in spinal surgery
- Cost of spinal SSI is high for the health care system and patients and negatively affects outcomes

Thank you!

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