Complications in Spine Surgery
Warwick June 2014

GLOBUS MEDICAL

Ways to Minimise Post-Operative Surgical Site Infections

Mr M J H McCarthy
Consultant Spinal Surgeon

Fusion Portfolio | Minimally Invasive Surgery | Biomaterials | Motion Preservation

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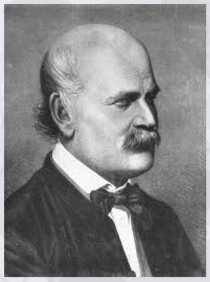

- Ignaz Semmelweis
- 1818-1865
- "saviour of mothers"
- Wash your hands

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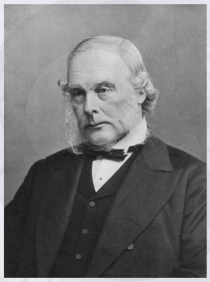

- Joseph Lister
- 1827-1912
- Sterilisation

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- Alexander Flemming
- 1881-1955
- Penicillin

Also Louis Pasteur, Robert Koch and Ferdinand Cohn

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ELSEVIER

The Spine Journal 12 (2012) 22-34

THE SPINE JOURNAL

2011 Outstanding Paper: Surgical Science

Morbidity and mortality of major adult spinal surgery. A prospective cohort analysis of 942 consecutive patients

John T. Street, MD, PhD[a,*], Brian J. Lenehan, MD[a], Christian P. DiPaola, MD[a], Michael D. Boyd, MD[a], Brian K. Kwon, MD, PhD[a], Scott J. Paquette, MD[a], Marcel F.S. Dvorak, MD[a], Y. Raja Rampersaud, MD[b], Charles G. Fisher, MD[a]

- Very detailed and strict study of AEs
- 940 pts over 1 year period
- *87% had at least 1 documented complication!*
  - 39% affected LOS
  - Most common - electrolyte imbalance and medication related SEs
  - Intraop complications 10.5%
  - Post op complications 73.5%
    - 13.5% wound complication
    - **29 SSIs = 3%**
- **WHAT WE DO IS VERY HIGH RISK!**

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Some Stats

- Spinal SSI 0.7 – 12+%
- Increased morbidity, mortality and health care costs
- SSIs = 1/3 of HAIs
- CDC Jan 2014 SSI:
  - 30 days after surgery without instrumentation
  - 1 year with instrumentation
    - Other classifications:
      - Acute (<3 weeks)
      - Subacute (3 weeks to 3 months)
      - Chronic (>3 months)

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Copyright

Table 1. Criteria for Defining a Surgical Site Infection (SSI)*

Superficial Incisional SSI
Infection occurs within 30 days after the operation *and* infection involves only skin or subcutaneous tissue of the incision *and* at least *one* of the following:
1. Purulent drainage, with or without laboratory confirmation, from the superficial incision.
2. Organisms isolated from an aseptically obtained culture of fluid or tissue from the superficial incision.
3. At least one of the following signs or symptoms of infection: pain or tenderness, localized swelling, redness, or heat *and* superficial incision is deliberately opened by surgeon, *unless* incision is culture-negative.
4. Diagnosis of superficial incisional SSI by the surgeon or attending physician.

Do *not* report the following conditions as SSI:
1. Stitch abscess (minimal inflammation and discharge confined to the points of suture penetration).
2. Infection of an episiotomy or newborn circumcision site.
3. Infected burn wound.
4. Incisional SSI that extends into the fascial and muscle layers (see deep incisional SSI).

Note: Specific criteria are used for identifying infected episiotomy and circumcision sites and burn wounds.[4,13]

Deep incisional SSI
Infection occurs within 30 days after the operation if no implant† is left in place or within 1 year if implant is in place and the infection appears to be related to the operation *and* infection involves deep soft tissues (e.g., fascial and muscle layers) of the incision *and* at least *one* of the following:
1. Purulent drainage from the deep incision but not from the organ/space component of the surgical site.
2. A deep incision spontaneously dehisces or is deliberately opened by a surgeon when the patient has at least one of the following signs or symptoms: fever (>38°C), localized pain, or tenderness, unless site is culture-negative.
3. An abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation, or by histopathologic or radiologic examination.
4. Diagnosis of a deep incisional SSI by a surgeon or attending physician.

Notes:
1. Report infection that involves both superficial and deep incision sites as deep incisional SSI.
2. Report an organ/space SSI that drains through the incision as a deep incisional SSI.

Organ/space SSI
Infection occurs within 30 days after the operation if no implant† is left in place or within 1 year if implant is in place and the infection appears to be related to the operation *and* infection involves any part of the anatomy (e.g., organs or spaces), other than the incision, which was opened or manipulated during an operation *and* at least *one* of the following:
1. Purulent drainage from a drain that is placed through a stab wound‡ into the organ/space.
2. Organisms isolated from an aseptically obtained culture of fluid or tissue in the organ/space.
3. An abscess or other evidence of infection involving the organ/space that is found on direct examination, during reoperation, or by histopathologic or radiologic examination.
4. Diagnosis of an organ/space SSI by a surgeon or attending physician.

* Horan TC et al.[22]
†National Nosocomial Infection Surveillance definition: a nonhuman-derived implantable foreign body (e.g., prosthetic heart valve, nonhuman vascular graft, mechanical heart, or hip prosthesis) that is permanently placed in a patient during surgery.
‡If the area around a stab wound becomes infected, it is not an SSI. It is considered a skin or soft tissue infection, depending on its depth.

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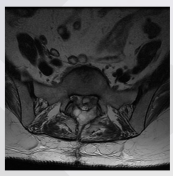
Jan2014 *Surveillance Definitions*

CDC/NHSN Surveillance Definitions for Specific Types of Infections

- Definitions:
  - Superficial Incisional
  - Deep Incisional
  - Organ / Space
- Localised stitch abscess and pin site infections not classified as SSIs (common)



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CDC Jan 2014

- All SSIs:
  - Staph aureus 30%
  - Coag neg staph 13.7%
  - Enterococcus 11.2%
  - E.coli 9.6%
  - Pseudomonas 5.6%

1. Direct innoculation at surgery
2. Contamination early post op
3. Contamination haematogenous seeding

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CDC Jan 2014

- Endogenous:
  - Pt flora
    - Skin
    - Membranes
    - GI tract
  - Seeding from distal focus infection
- Exogenous sources:
  - Surgical personnel
    - Soiled attire
    - Aseptic tech
    - Hand hygiene
  - OR environment and ventilation
  - Tools, equipment, materials / implants

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Some Ps

- Patient
- Pathology (incl micro factors)
- Procedure

- Preoperative
- Perioperative
- Postoperative

- Proper
- Planning
- Prevents
- Piss
- Poor
- Performance

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Left L5/1 LRS Disc

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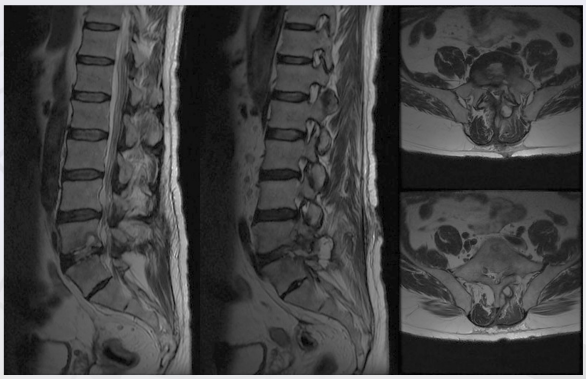
6 weeks



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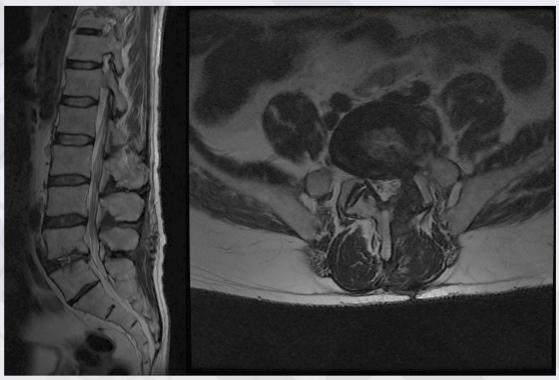
3 months



Staph epidermidis

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2009

SPINE Volume 34, Number 17, pp 1869–1872
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Risk Factors for Postoperative Spinal Wound Infections After Spinal Decompression and Fusion Surgeries

Anand Veeravagu, MD,*† Chirag G. Patil, MD,*† Shivanand P. Lad, MD, PhD,*† and Maxwell Boakye, MD*†

- 752 / 24,774 = 3% SSI
- SSI ass with:
  - Diabetes
  - Smoking
  - ASA ≥ 3
  - Preop Hct <36
  - Disseminated cancer
  - Instrumented fusion
  - Op > 3 hours

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2011

Infections in the operated spine: Update on risk management and therapeutic strategies

J.-Y. Lazennec[a,*], E. Fournols[a], T. Lenoir[b], A. Aubry[c], M.-L. Pissonnier[a], B. Issartel[d], M.-A. Rousseau[a], French Spine Surgery Society

Orthopaedics & Traumatology: Surgery & Research (2011) 97S, S107–S116

- Preop hospitalization < 4/7
- Stop smoking
- Manage obesity, diabetes, malnutrition
- ID + treat infections / carriage
- Do not give prolonged post op abs
- Limit duration of tubes, lines, drains
  - Drains out <48hrs, no evidence drain usage ↓SSI
- Reduce OR personnel

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2012

Spine
SPINE Volume 37, Number 24, pp 2017–2033
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LITERATURE REVIEW

A Methodological Systematic Review on Surgical Site Infections Following Spinal Surgery

Part 1: Risk Factors

Albert F. Pull ter Gunne, MD,* Allard J. F. Hosman, MD, PhD,† David. B. Cohen, MD, MPH,‡ Michael Schuetz, Drmed Habil, FRACS(Orth.Surg),§‖ Cees J. H. M. van Laarhoven, MD, PhD,* and Joost J. van Middendorp, MD, PhD§¶

- 24 eligible studies
- 34 significant SSI factors identified
- Diabetes, Obesity, Previous SSI most important
  - Def: BMI >30
- Smoking only a risk factor in 2/11 studies investigating smoking

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Spine
SPINE Volume 37, Number 24, pp 2057–2033
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LITERATURE REVIEW

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Albert F. Pull ter Gunne, MD,* Allard J. F. Hosman, MD, PhD,† David. B. Cohen, MD, MPH,‡ Michael Schuetz, Drmed Habil, FRACS(Orth.Surg),§‖ Cees J. H. M. van Laarhoven, MD, PhD,* and Joost J. van Middendorp, MD, PhD§‖¶

- Prophylactic Strategies Identified:
  - Antibiotics
  - Skin antisepsis
  - Hair removal
  - Air ventilation system
  - Number of changes of OR personnel during surgery
  - Surgical clothing
  - Closed suction drains (if using a drain)

SPINE Volume 35, Number 9S, pp S125-S137
©2010, Lippincott Williams & Wilkins

The Influence of Perioperative Risk Factors and Therapeutic Interventions on Infection Rates After Spine Surgery

A Systematic Review

James M. Schuster, MD, PhD,* Glenn Rechtine, MD,† Daniel C. Norvell, PhD,‡ and Joseph R. Dettori, PhD‡

2010

- Evidence review 1990-2009
- ↑risks – age, obesity, diabetes, malnutrition, ASA, post appr, blood transfusion
- Unable to predict exact risk and unable to stratify

Table 7. List of Adjunct Measures for Preventing Postoperative Surgical-Site Infection Published in the Literature

Spine Surgery	General Orthopedic Surgery
Ultraclean air technology[22]	Ultraclean air technology[25–29]
Betadine solution[20,21]	Betadine solution[32,33]
Closed wound suction drainage[18,19]	Occlusive garments[25]
No shaving[23]	Double gloving[30,31]
Silver impregnated dressings[7]	Body exhaust suits[29]
	Ultraviolet lighting[34]
	Anitseptic scrubs[35,36]
	Nasal swabs[37,38]

Only irrigation with dilute betadine showed moderate support to reduce infection

SPINE Volume 29, Number 8, pp 938–945
©2004, Lippincott Williams & Wilkins, Inc.

Spine Update

Prevention of Postoperative Infection in Patients Undergoing Spinal Surgery

Erwin M. Brown, FRCPath,* Ian K. Pople, FRCS,† John de Louvois, FRCPath,‡ Alan Hedges, PhD,§ Roger Bayston, FRCPath,¶ Stephen M. Eisenstein, FRCS,‖ and Peter Lees, FRCS# for the British Society for Antimicrobial Chemotherapy Working Party on Neurosurgical Infections

2004

- Prolonged op
  - Irrigate with saline +/- iodine regularly
  - Do not use abs in irrigation
- Minimise use of drains

SPINE Volume 34, Number 5, pp 479–483
©2009, Lippincott Williams & Wilkins

Reduction of Postoperative Spinal Implant Infection Using Gentamicin Microspheres

Alec C. Stall, MD, Ed Becker, MD, Steven C. Ludwig, MD, Daniel Gelb, MD, and Kornelis A. Poelstra, MD, PhD

2009

- Rabbit model
- SSI 75% vs 38%
- Biomaterial infection (Ti rods) 58% vs 23%

National Collaborating Centre for Women's and Children's Health

Surgical site infection

prevention and treatment of surgical site infection

Clinical Guideline
October 2008
Funded to produce guidelines for the NHS by NICE

NCG74

2008

NICE 2008 NCG74

- At least 5% pts undergoing surgery develop SSI
- Perhaps some evidence now outdated
  - Esp for Ortho / Spine

NICE Preop

- Patient prep – wash, clothes
- Hair removal - clippers
- Abs – timing, pharmacokinetics, rpt dosing
- Staff prep – clothing in / out th, jewellery, nails, polish

Do not use the following routinely to reduce the risk of surgical site infections:

- hair removal
- nasal decontamination with topical antimicrobial agents targeting *Staphylococcus aureus* X
- mechanical bowel preparation.

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The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JANUARY 7, 2010 VOL. 362 NO. 1

Preventing Surgical-Site Infections in Nasal Carriers of *Staphylococcus aureus*

Lonneke G.M. Bode, M.D., Jan A.J.W. Kluytmans, M.D., Ph.D., Heiman F.L. Wertheim, M.D., Ph.D., Diana Bogaers, I.C.P., Christina M.J.E. Vandenbroucke-Grauls, M.D., Ph.D., Robert Roosendaal, Ph.D., Annet Troelstra, M.D., Ph.D., Adrienne T.A. Box, B.A.Sc., Andreas Voss, M.D., Ph.D., Ingeborg van der Tweel, Ph.D., Alex van Belkum, Ph.D., Henri A. Verbrugh, M.D., Ph.D., and Margreet C. Vos, M.D., Ph.D.

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NICE Intraop

- Brush / pick nails, scrub, sterile gowns, double glove, wash hands between ops
- Skin prep
- Maintain pt homeostasis – temp, O2, perfusion
- Use a wound dressing

Do not use the following to reduce the risk of surgical site infections:

- non-iodophor-impregnated incise drapes. If an incise drape is required, use an iodophor-impregnated drape unless the patient has an iodine allergy
- insulin routinely to optimise postoperative blood glucose levels in patients who do not have diabetes
- diathermy for surgical incision
- wound irrigation X
- intracavity lavage
- intraoperative skin redisinfection or topical cefotaxime in abdominal surgery.

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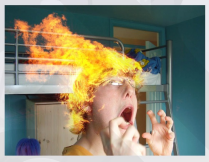
The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Chlorhexidine–Alcohol versus Povidone–Iodine for Surgical-Site Antisepsis

Rabih O. Darouiche, M.D., Matthew J. Wall, Jr., M.D., Kamal M.F. Itani, M.D., Mary F. Otterson, M.D., Alexandra L. Webb, M.D., Matthew M. Carrick, M.D., Harold J. Miller, M.D., Samir S. Awad, M.D., Cynthia T. Crosby, B.S., Michael C. Mosier, Ph.D., Atef AlSharif, M.D., and David H. Berger, M.D.



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NICE Postop

- Aseptic tech for CoD
- Sterile saline up to 48hrs
- Tap water after 48hrs
- May shower safely after 48hrs (???)
- Refer TVN for wounds healing by secondary intention

Do not use the following to reduce the risk of surgical site infections:

- topical antimicrobial agents for surgical wounds that are healing by primary intention
- Eusol and gauze, or moist cotton gauze or mercuric antiseptic solutions for surgical wounds that are healing by secondary intention.

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Main Summary CDC Jan 2014

- Modifiable Risk Factors:
  - Ab Prophylaxis
    - Choice – local gudielines
    - Timing – 1 hour prior incision, stop within 24hrs
    - Dose based on BMI, procedure >3hrs, xs blood loss
  - Skin prep ineffective
    - Razors – use clippers
  - Excess OR traffic
  - Inadequate dressing – keep covered 24-48hrs
  - Poor glucose control - <200mg/dL or <11mmol/L
  - Colonization pre-existng organisms – Tx remote infections, nasal screening
  - Inadequate intraop oxygen levels – Fi02 50%
    - incl. normothermia

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2009

Intraoperative Fraction of Inspired Oxygen Is a Modifiable Risk Factor for Surgical Site Infection after Spinal Surgery

Lisa L. Maragakis, M.D., M.P.H.,* Sara E. Cosgrove, M.D., M.S.,* Elizabeth A. Martinez, M.D., M.H.S.,† Margaret G. Tucker, B.S.,‡ David B. Cohen, M.D., M.P.H.,§ Trish M. Perl, M.D., M.Sc.‖

- 104 SSI vs 104 controls
- SSI ass with:
  - Prolonged procedure (p<0.001)
  - ASA ≥ 3 (p<0.001)
  - Lumbosacral (p<0.02)
  - Posterior appr (p<0.02)
  - Instrumentation (p<0.03)
  - Obesity (p<0.01)
  - Razor shaving (p<0.02)
  - **Fi02 < 50% (p<0.001)**

At last we can blame the Anaesthnetist!

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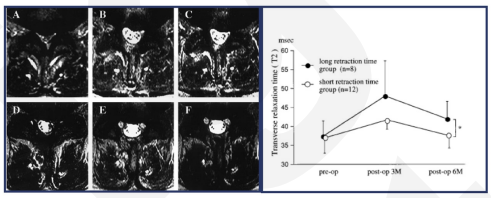
RETRACTION



Longer Times >> More Damage

Gejo Spine 1999

- Soft tissue management:
  - Wound size, op duration, tissue damage, wound edges, oxygenation, blood supply

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Respect the Skin Edges

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Do The WHO

Surgical Safety Checklist

World Health Organization | Patient Safety

Before induction of anaesthesia (with at least nurse and anaesthetist)	Before skin incision (with nurse, anaesthetist and surgeon)	Before patient leaves operating room (with nurse, anaesthetist and surgeon)
Has the patient confirmed his/her identity, site, procedure, and consent? ☐ Yes	☐ Confirm all team members have introduced themselves by name and role.	Nurse Verbally Confirms: ☐ The name of the procedure
Is the site marked? ☐ Yes ☐ Not applicable	☐ Confirm the patient's name, procedure, and where the incision will be made.	☐ Completion of instrument, sponge and needle counts
Is the anaesthesia machine and medication check complete? ☐ Yes	Has antibiotic prophylaxis been given within the last 60 minutes? ☐ Yes ☐ Not applicable	☐ Specimen labelling (read specimen labels aloud, including patient name)
Is the pulse oximeter on the patient and functioning? ☐ Yes	Anticipated Critical Events	☐ Whether there are any equipment problems to be addressed
Does the patient have a: Known allergy? ☐ No ☐ Yes	To Surgeon: ☐ What are the critical or non-routine steps? ☐ How long will the case take? ☐ What is the anticipated blood loss?	To Surgeon, Anaesthetist and Nurse: ☐ What are the key concerns for recovery and management of this patient?
Difficult airway or aspiration risk? ☐ No ☐ Yes, and equipment/assistance available	To Anaesthetist: ☐ Are there any patient-specific concerns?	
Risk of >500ml blood loss (7ml/kg in children)? ☐ No ☐ Yes, and two IVs/central access and fluids planned	To Nursing Team: ☐ Has sterility (including indicator results) been confirmed? ☐ Are there equipment issues or any concerns?	
	Is essential imaging displayed? ☐ Yes ☐ Not applicable	

This checklist is not intended to be comprehensive. Additions and modifications to fit local practice are encouraged. Revised 1 / 2009 © WHO, 2009

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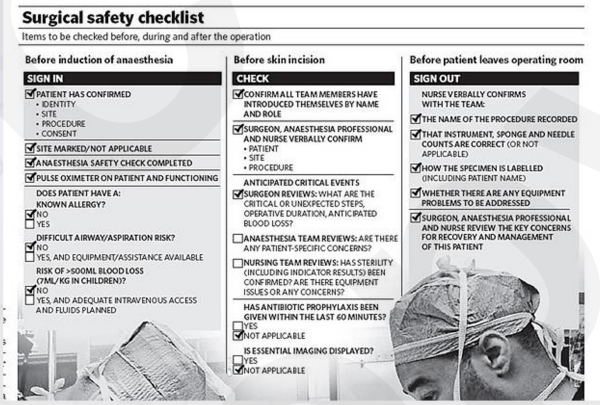

Surgical safety checklist

Items to be checked before, during and after the operation

Before induction of anaesthesia

SIGN IN

- ☑ PATIENT HAS CONFIRMED
  - IDENTITY
  - SITE
  - PROCEDURE
  - CONSENT
- ☑ SITE MARKED/NOT APPLICABLE
- ☑ ANAESTHESIA SAFETY CHECK COMPLETED
- ☑ PULSE OXIMETER ON PATIENT AND FUNCTIONING

DOES PATIENT HAVE A: KNOWN ALLERGY?
☑ NO
☐ YES

DIFFICULT AIRWAY/ASPIRATION RISK?
☑ NO
☐ YES, AND EQUIPMENT/ASSISTANCE AVAILABLE

RISK OF >500ML BLOOD LOSS (7ML/KG IN CHILDREN)?
☑ NO
☐ YES, AND ADEQUATE INTRAVENOUS ACCESS AND FLUIDS PLANNED

Before skin incision

CHECK

- ☑ CONFIRM ALL TEAM MEMBERS HAVE INTRODUCED THEMSELVES BY NAME AND ROLE
- ☑ SURGEON, ANAESTHESIA PROFESSIONAL AND NURSE VERBALLY CONFIRM
  - PATIENT
  - SITE
  - PROCEDURE

ANTICIPATED CRITICAL EVENTS

- ☑ SURGEON REVIEWS: WHAT ARE THE CRITICAL OR UNEXPECTED STEPS, OPERATIVE DURATION, ANTICIPATED BLOOD LOSS?
- ☐ ANAESTHESIA TEAM REVIEWS: ARE THERE ANY PATIENT-SPECIFIC CONCERNS?
- ☐ NURSING TEAM REVIEWS: HAS STERILITY (INCLUDING INDICATOR RESULTS) BEEN CONFIRMED? ARE THERE EQUIPMENT ISSUES OR ANY CONCERNS?

HAS ANTIBIOTIC PROPHYLAXIS BEEN GIVEN WITHIN THE LAST 60 MINUTES?
☐ YES
☑ NOT APPLICABLE

IS ESSENTIAL IMAGING DISPLAYED?
☐ YES
☑ NOT APPLICABLE

Before patient leaves operating room

SIGN OUT

NURSE VERBALLY CONFIRMS WITH THE TEAM:

- ☑ THE NAME OF THE PROCEDURE RECORDED
- ☑ THAT INSTRUMENT, SPONGE AND NEEDLE COUNTS ARE CORRECT (OR NOT APPLICABLE)
- ☑ HOW THE SPECIMEN IS LABELLED (INCLUDING PATIENT NAME)
- ☑ WHETHER THERE ARE ANY EQUIPMENT PROBLEMS TO BE ADDRESSED
- ☑ SURGEON, ANAESTHESIA PROFESSIONAL AND NURSE REVIEW THE KEY CONCERNS FOR RECOVERY AND MANAGEMENT OF THIS PATIENT

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Cardiff Experience

- 4557 procedures over 5 years 2007-1012
- SSI 5% (223)
- 1/10 SSI required debridement (21)
- 1/50 required ROM / Replacement (5)

SPINE Volume 33, Number 22, pp 2473-2478
©2008, Lippincott Williams & Wilkins

Is Aggressive Surgery Necessary for Acute Postoperative Deep Spinal Wound Infection?

Hsu-Shan Hong, MD,* Ming-Chau Chang, MD,*† Chien-Lin Liu, MD, and Tain-Hsiung Chen, MD

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Common Spinal SSI Rates

72/3230 = 2%

Original Article

J Chin Med Assoc 2004;67:398-402

Postoperative Spinal Deep Wound Infection: A Six-year Review of 3230 Selective Procedures

36/1568 = 2.3%

Risk factors for deep surgical site infections after spinal fusion

J. J. P. Schimmel · P. P. Horsting · M. de Kleuver · G. Wonders · J. van Limbeek

752/24,774 = 3%

SPINE Volume 34, Number 17, pp 1869–1872 ©2009, Lippincott Williams & Wilkins

Risk Factors for Postoperative Spinal Wound Infections After Spinal Decompression and Fusion Surgeries

Anand Veeravagu, MD,*† Chirag G. Patil, MD,*† Shivanand P. Lad, MD, PhD,*† and Maxwell Boakye, MD*†

132/3174 = 4%

SPINE Volume XX, Number X, pp 000–000 ©2010, Lippincott Williams & Wilkins

The Presentation, Incidence, Etiology, and Treatment of Surgical Site Infections After Spinal Surgery

Albert F. Pull ter Gunne, MD,* Ahmed S. Mohamed, MD,* Richard L. Skolasky, ScD,* Cees J. H. M. van Laarhoven, MD, PhD,† and David B. Cohen, MD, MPH

48/1095 = 4.4%

SPINE Volume 30, Number 12, pp 1460–1465 ©2005, Lippincott Williams & Wilkins, Inc.

Risk Factors for Infection After Spinal Surgery

Andrew Fang, MD, Serena S. Hu, MD, Nathan Endres, MD, and David S. Bradford, MD

Rate may depend on how closely data is collected and scrutinized

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Spine DEFORMITY

SPINE Volume 36, Number 7, pp 556–563 ©2011, Lippincott Williams & Wilkins

Rates of Infection After Spine Surgery Based on 108,419 Procedures

A Report from the Scoliosis Research Society Morbidity and Mortality Committee

Justin S. Smith, MD, PhD,* Christopher I. Shaffrey, MD,* Charles A. Sansur, MD,† Sigurd H. Berven, MD,‡ Kai-Ming G. Fu, MD, PhD,* Paul A. Broadstone, MD,§ Theodore J. Choma, MD,¶ Michael J. Goytan, MD,|| Hilali H. Noordeen, MD,** Dennis R. Knapp, Jr., MD,†† Robert A. Hart, MD,‡‡ William F. Donaldson III, MD,§§ David W. Polly Jr, MD,||| Joseph H. Perra, MD,*** Oheneba Boachie-Adjei, MD†††

- SSI 2.1% (sup 0.8 deep 1.3)
- ↑revisions, fusions, implants
- Kyphosis > Scoliosis > Spondylolisthesis > Degen
  - Scoliosis and kyphosis - ↑neuromuscular (upto 14%)
- ↓MIS – discectomy and TLIF

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Spine DEFORMITY

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Rates of Infection After Spine Surgery Based on 108,419 Procedures

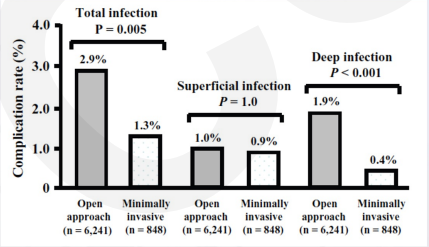
A Report from the Scoliosis Research Society Morbidity and Mortality Committee

J Neurosurg Spine 11:471–476, 2009

Surgical site infection rates after minimally invasive spinal surgery

Clinical article

John E. O'Toole, M.D.,† Kurt M. Eichholz, M.D.,† and Richard G. Fessler, M.D., Ph.D.†



MIS:
Less Pain
Less Infection
Less Bleeding
Short stay

For TLIF and Discectomy

Life moves us

Spine EPIDEMIOLOGY

SPINE Volume 38, Number 22, pp E1425–E1431 ©2013, Lippincott Williams & Wilkins

2013

Surgical Site Infections in Spine Surgery

Identification of Microbiologic and Surgical Characteristics in 239 Cases

Amir Abdul-Jabbar, MD,* Sigurd H. Berven, MD,† Serena S. Hu, MD,† Dean Chou, MD,‡ Praveen V. Mummaneni, MD,‡ Steven Takemoto, PhD,† Christopher Ames, MD,‡ Vedat Deviren, MD,† Bobby Tay, MD,† Phil Weinstein, MD,† Shane Burch, MD,† and Catherine Liu, MD§

- 239 / 7529 cases SSI (3%)
  - Staph aureus 45%
  - Staph epi 31%
    - MRSA 34% and more common in revisions
  - Gram neg 30%
  - Sacral procedures – ↑gram neg and polymicrobia
  - Cervical procedures - ↓gram neg

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Spine SURGERY

SPINE Volume 37, Number 15, pp 1340–1345 ©2012, Lippincott Williams & Wilkins

2012

6628 hospital visits SSI 2.9%

Surgical Site Infection in Spinal Surgery

Description of Surgical and Patient-Based Risk Factors for Postoperative Infection Using Administrative Claims Data **Coding study**

Amir Abdul-Jabbar, BA, Steven Takemoto, PhD, Michael H. Weber, MD, PhD, FRCSC, Serena S. Hu, MD, Praveen V. Mummaneni, MD, Vedat Deviren, MD, Christopher P. Ames, MD, Dean Chou, MD, Philip R. Weinstein, MD, Shane Burch, MD, and Sigurd H. Berven, MD

- Procedure:
  - Sacrum = 9.6%
  - Fuse > 7 = 7.8%
  - Fuse > 12 = 10.4%
  - Osteotomy = 6.5%
  - Op > 5hrs = 5.1%
  - Trans RBC = 5%
  - Trans Serum = 7.4%
  - Trans auto = 4.1%
- Patient:
  - Anaemia = 4.3%
  - Diabetes = 4.2%
  - Coronary art = 4.7%
  - Coagulopathy = 7.8%
  - Neoplasm = 5%

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Spinal Trauma

Early surgical site infections in adult spinal trauma: A prospective, multicentre study of infection rates and risk factors☆

G. Lonjon[a,*], C. Dauzac[a], E. Fournols[b], P. Guigui[a], F. Bonnomet[c], P. Bonnevialle[d], The French Orthopaedic Surgery Traumatology Society[e]

Orthopaedics & Traumatology: Surgery & Research (2012) 98, 788–794

- 6/169 (3.6%)

SPINE Volume 28, Number 13, pp 1475–1480 ©2003, Lippincott Williams & Wilkins, Inc.

Risk Factors for Surgical Site Infection in the Patient With Spinal Injury

Oren G. Blam, MD,* Alexander R. Vaccaro, MD,* Jed S. Vanichkachorn, MD,* Todd J. Albert, MD,* Alan S. Hilibrand, MD,* John M. Minnich, MD,* and Sheila A. Murphey, MD†

- 24/256 (9.4%)

ELSEVIER THE SPINE JOURNAL

The Spine Journal 11 (2011) 641–646

Clinical Study

Reduced surgical site infections in patients undergoing posterior spinal stabilization of traumatic injuries using vancomycin powder

Kevin R. O'Neill, MD[a], Jason G. Smith, BS[b], Amir M. Abtahi, BS[b], Kristin R. Archer, PhD, DPT[a], Dan M. Spengler, MD[a], Matthew J. McGirt, MD[c], Clinton J. Devin, MD[a,*]

- 7/54 (13%) controls vs 0/56 (0%) vanc in wound p=0.02

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2009

SPINE Volume 34, Number 6, pp 635–639
©2009, Lippincott Williams & Wilkins

Surgical Site Infection in Spinal Metastasis
Risk Factors and Countermeasures

Satoru Demura, MD, Norio Kawahara, MD, Hideki Murakami, MD, Koshi Nambu, MD, Satoshi Kato, MD, Katsuhito Yoshioka, MD, Tadaki Okayama, MD, and Katsuro Tomita, MD

- Phase 1: 110 pts (113 ops)
  - 8/110 SSI (7.1%)
  - 7/22 SSI prior DXT (32%)
- Phase 2: 94 pts (97 ops)
  - Given PGE1 60micrograms bd post op mean 7/7
  - 3/97 SSI (3.1%)
  - 1/22 SSI prior DXR (4.5%)

NS

p<0.05

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2011

Spine
SURGERY

SPINE Volume 36, Number 17, pp 1410–1419
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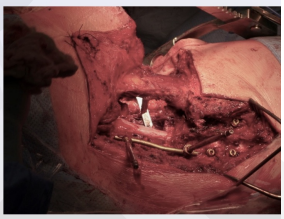
Postoperative Surgical Site Infections in Patients Undergoing Spinal Tumor Surgery
Incidence and Risk Factors

Ibrahim A. Omeis, MD, Mashaal Dhir, MD, Daniel M. Sciubba, MD, Oren N. Gottfried, MD, Matthew J. McGirt, MD, Frank J. Attenello, MD, Jean-Paul Wolinsky, MD, and Ziya L. Gokaslan, MD

- 678 pts
- SSI:
  - Primary non bony = 8.9%
  - Metastatic = 9.5%
  - Primary bony = 13.7%



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Paediatric Fusion

INFECTION CONTROL AND HOSPITAL EPIDEMIOLOGY FEBRUARY 2009, VOL. 30, NO. 2

ORIGINAL ARTICLE

Risk Factors Associated With Surgical Site Infection After Pediatric Posterior Spinal Fusion Procedure

W. Matthew Linam, MD; Peter A. Margolis, MD, PhD; Mary Allen Staat, MD, MPH; Maria T. Britto, MD, MPH; Richard Hornung, DrPH; Amy Cassedy, PhD; Beverly L. Connelly, MD

Vol. 24 No. 8 INFECTION CONTROL AND HOSPITAL EPIDEMIOLOGY 591

- 4.4%

SURGICAL-SITE INFECTION FOLLOWING SPINAL FUSION: A CASE–CONTROL STUDY IN A CHILDREN'S HOSPITAL

Annie-Claude Labbé, MD, FRCP(C); Anne-Marie Demers, MD, FRCP(C); Ramona Rodrigues, MSc; Vincent Arlet, MD; Kim Tanguay, BSc; Dorothy L. Moore, PhD, MD, FRCP(C)

- 5.2%

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Paediatric Deformity SSI

SPINE Volume 35, Number 12, pp 1211–1217
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Infection After Spinal Fusion for Pediatric Spinal Deformity
Thirty Years of Experience at a Single Institution

Patrick J. Cahill, MD,* Drew E. Warnick, MD,† Michael J. Lee, MD,‡ John Gaughan, PhD,§ Lawrence E. Vogel, MD,¶ Kim W. Hammerberg, MD,¶‖ and Peter F. Sturm, MD†¶

- 57 / 1543 = 3.7%

Diagnosis	No. Patients	No. Infections	Rate
Cerebral palsy	107	13	12.1
Myelomeningocele	84	15	17.9
Myopathies	37	1	2.7
SCI	37	6	16.2
Polio	12	4	33.0
Others	30	1	3.3

	No. Cases	No. Infections	Infection Rate (%)
Idiopathic	948	5	0.5
Congenital	139	2	1.4
Syndromic	166	5	3.0
Neuromuscular	323	43	13.3
Other	11	2	18.2

SPINE Volume 25, Number 19, pp 2461–2466
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Deep Wound Infections After Neuromuscular Scoliosis Surgery
A Multicenter Study of Risk Factors and Treatment Outcomes

Paul D. Sponseller, MD, Dawn M. LaPorte, MD, Marc W. Hungerford, MD, Kevin Eck, MD, Keith H. Bridwell, MD, and Lawrence G. Lenke, MD

- 25 / 210 = 12%

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Adult Deformity

Eur Spine J (2010) 19:982–988
DOI 10.1007/s00586-009-1269-1

ORIGINAL ARTICLE

Incidence of surgical site infection following adult spinal deformity surgery: an analysis of patient risk

Albert F. Pull ter Gunne · C. J. H. M. van Laarhoven · David B. Cohen

- 46/830 = 5.5%
- Risk – obesity and previous SSI

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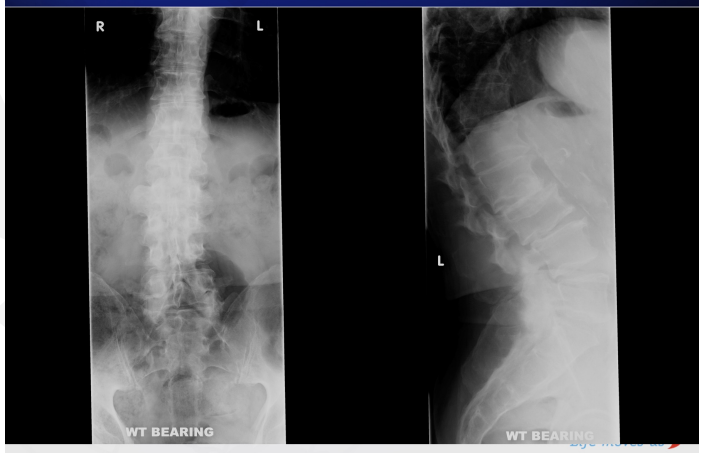
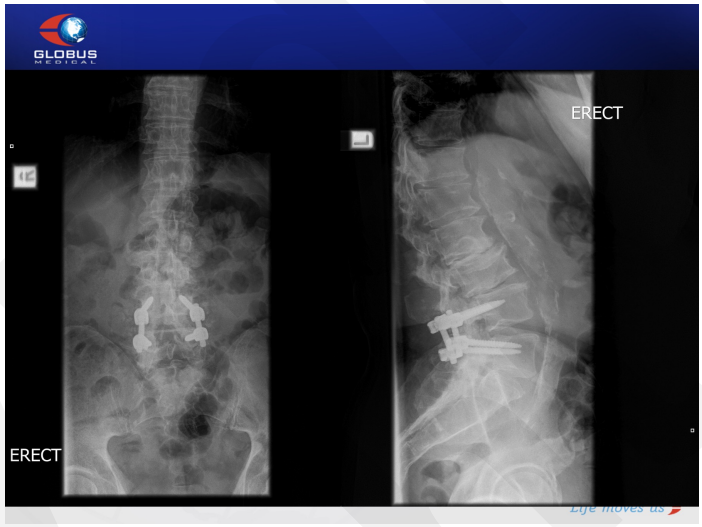
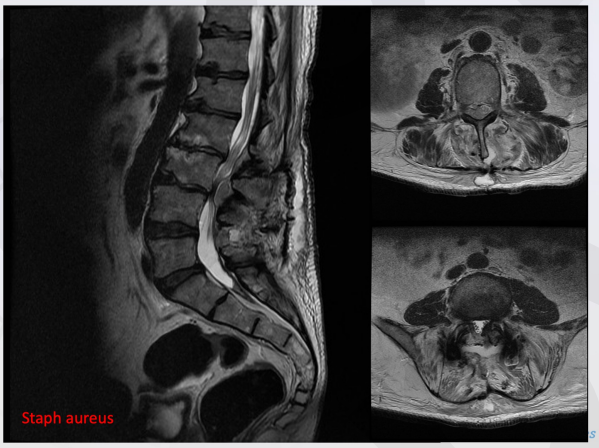
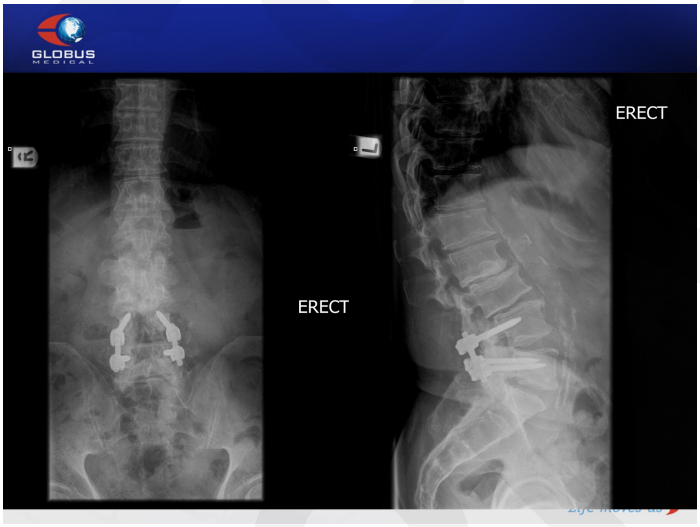
L4/5 Stenosis Facet Cyst



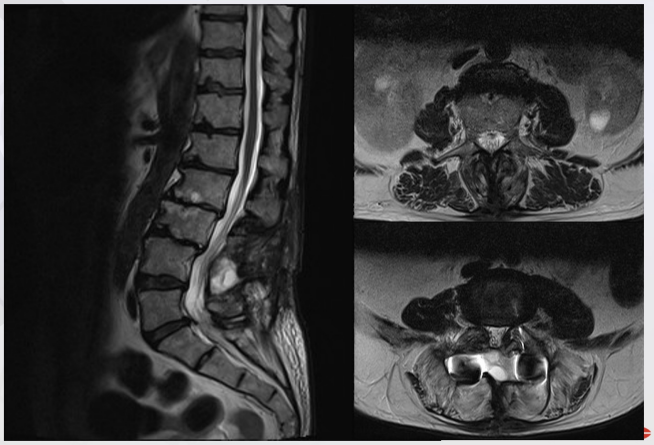


2 Weeks

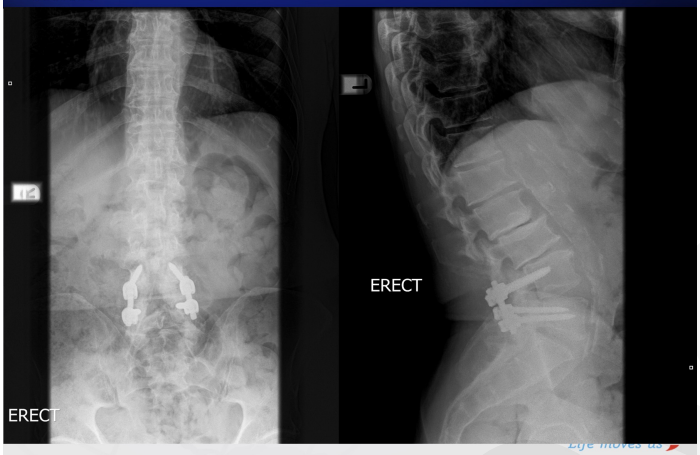




6 Weeks



6 Months



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Risk Factors for Surgical Site Infection Following Orthopaedic Spinal Operations

By Margaret A. Olsen, PhD, MPH, Jeffrey J. Nepple, MD, K. Daniel Riew, MD, Lawrence G. Lenke, MD, Keith H. Bridwell, MD, Jennie Mayfield, BSN, MPH, CIC, and Victoria J. Fraser, MD

- 46/2316 ops -2% SSI
  - vs 227 random controls

- Pre and within 5/7 post op Glucose
- Diabetes
- Poor timing of Abs
- Obesity
- ***2 or more residents scrubbed***

At last we can blame the Fellow!

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Some Rules About…

When a Reg / Fellow starts:

1. Don't let them put their dirty hands in the wound
2. Don't let them do the operation
3. Don't let them close the wound
4. Supervise them closely!

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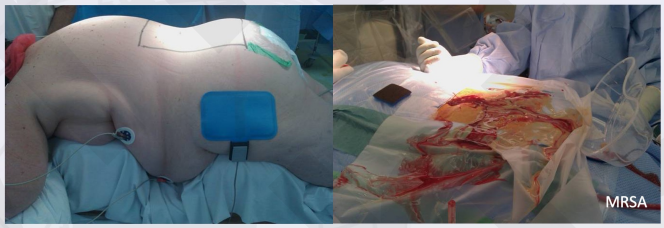
Take Home Message



Avoid operating on obese diabetics with previous history of spinal infection

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Thank you

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Spine
SPINE Volume 37, Number 24, pp 2017–2033
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LITERATURE REVIEW
A Methodological Systematic Review on Surgical Site Infections Following Spinal Surgery
Part 1: Risk Factors
Albert F. Pull ter Gunne, MD,* Allard J. F. Hosman, MD, PhD,† David. B. Cohen, MD, MPH,‡ Michael Schuetz, Drmed Habil, FRACS(Orth.Surg),§‖ Cees J. H. M. van Laarhoven, MD, PhD,* and Joost J. van Middendorp, MD, PhD§‖¶

- Patient:
  - Age, sex, race, workers comp, height, prev spinal op, prev non spinal op, prev op (NOS), prev spinal infection / SSI, smoking, alcohol, immunosuppressant, obesity, diabetes, rheumatoid, cardiovasc dis, pulm dis, UTI, urinary incontinence, complete neuro deficit, functional status, Karnofsky score, ASA, NNIS risk index, malignancy, neoadjuvant therapy, tumour size, weight loss

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- Anaesthetic:
  - Propofol, vent and oxygenation characteristics, body temp, intraop fluid infusion rate, clotting agents
- Surgical:
  - Indication, date, room personnel, specific OR, timing, hair removal, antisepsis, antibiotics, anatomical approach, type, number surgeries, duration, EBL, level of surgery, no of levels, graft type, dural tear, microscope, closed suction drain

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- Postoperative:
  - Steroids, bed bath, post op incontinence, any incontinence
- Hospitalization:
  - Preop, post op location, LOS

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Albert F. Pull ter Gunne, MD,* Allard J. F. Hosman, MD, PhD,† David. B. Cohen, MD, MPH,‡ Michael Schuetz, Drmed Habil, FRACS(Orth.Surg),§‖ Cees J. H. M. van Laarhoven, MD, PhD,* and Joost J. van Middendorp, MD, PhD§‖¶

- Laboratory:
  - Preop: malnutrition, albumin, protein, WCC, Cr, Hct, Glu
  - Post op: Glu, Hb, Transfusion – pRBC after op, FFP intraop

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Spine
SPINE Volume 37, Number 24, pp 2034–2045
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LITERATURE REVIEW
A Methodological Systematic Review on Surgical Site Infections Following Spinal Surgery
Part 2: Prophylactic Treatments
Joost J. van Middendorp, MD, PhD,*†‡ Albert F. Pull ter Gunne, MD,§ Michael Schuetz, Drmed Habil, FRACS(Orth.Surg),*† David B. Cohen, MD, MPH,‖ Allard J. F. Hosman, MD, PhD,¶ and Cees J. H. M. van Laarhoven, MD, PhD§

- 18 eligible studies
- Main Reported Prophylactic Strategies in Lit:
  - Antibiotics, closed suction wound drains, laminar flow, body exhaust suits, routine UV lights in theatre, povidone-iodine wound irrigation, Ab wound irrigation, chlorhex shower night before op, frequent dressing changes, debridement non viable tissue intraop, shaving preop, silverlon dressings, use of PGE1

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Cardiff Ab Prophylaxis 2014

- Non Instrumented Low Risk:
  - Cefuroxime 1.5g Induction
  - Allergy: Teicoplanin 400mg + Gentamicin 3mg/Kg
- High Risk and Instrumented:
  - Cefuroxime 1.5g and Teicoplanin 400mg Induction
    - Post Op Cef 750mg x2-3 8° and Teic 400mg x1 @12hrs
  - Allergy: Teicoplanin 400mg + Gentamicin 3mg/Kg
    - Post Op Teic 400mg x1 @12hrs
- If post op catheter insertion:
  - 160mg Gentamicin

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Risk Factors for Surgical Site Infection Following Orthopaedic Spinal Operations

By Margaret A. Olsen, PhD, MPH, Jeffrey J. Nepple, MD, K. Daniel Riew, MD, Lawrence G. Lenke, MD, Keith H. Bridwell, MD, Jennie Mayfield, BSN, MPH, CIC, and Victoria J. Fraser, MD

TABLE II Univariate Comparisons of Individual Risk Factors in Patients with and without Surgical Site Infection Following Orthopaedic Spinal Operations

Patient-Level Characteristics	No. (%) of Patients with Surgical Site Infection (N = 46)	No. (%) of Uninfected Patients (N = 227)	Odds Ratio (95% Confidence Interval)	P Value
Body mass index				
Normal (≤25 kg/m²)	9 (20)	84 (37)	1.0	
Overweight (>25 and <30 kg/m²)	11 (24)	77 (34)	1.3 (0.5, 3.4)	0.546
Obese (≥30 and ≤35 kg/m²)	18 (39)	37 (16)	4.5 (1.9, 11.0)	0.001
Morbidly obese (>35 kg/m²)	8 (17)	29 (13)	2.6 (0.9, 7.3)	0.075
Diabetes and hyperglycemia				
Neither (no diabetes or hyperglycemia)	20 (43)	179 (79)	1.0	
Serum glucose >75th percentile	12 (26)	33 (15)	3.3 (1.5, 7.3)	0.004
Diabetes	14 (30)	15 (7)	8.4 (3.5, 19.8)	<0.001
Diagnoses				
Herniated disc	6 (13)	63 (28)	0.4 (0.2, 1.0)	0.036
Fracture	6 (13)	9 (4)	3.6 (1.2, 10.8)	0.025
American Society of Anesthesiologists class 3 or 4	22 (48)	59 (26)	2.6 (1.4, 5.0)	0.003
Nerve root compression	22 (48)	153 (67)	0.4 (0.2, 0.8)	0.012
Transfusion				
Cell Saver or autologous blood	10 (22)	35 (15)	2.2 (0.9, 5.0)	0.071
Packed red blood cells or platelets	15 (33)	33 (14.5)	3.4 (1.6, 7.4)	0.001
Postoperative incontinence	8 (17)	14 (6)	3.2 (1.3, 8.2)	0.018
Preoperative or postoperative incontinence	13 (28)	27 (12)	2.9 (1.4, 6.2)	0.004

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Risk Factors for Surgical Site Infection Following Orthopaedic Spinal Operations

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TABLE III Univariate Comparisons of Surgical Risk Factors in Patients with and without Surgical Site Infection Following Orthopaedic Spinal Operations

Operative Characteristics	No. (%) of Patients with Surgical Site Infection (N = 46)	No. (%) of Uninfected Patients (N = 227)	Odds Ratio (95% Confidence Interval)	P Value
Cervical level	11 (24)	97 (43)	0.4 (0.2, 0.9)	0.017
Posterior approach	42 (91)	172 (76)	3.4 (1.2, 9.8)	0.020
Suboptimal timing of prophylactic antibiotic therapy*	15 (33)	31 (14)	3.1 (1.5, 6.3)	0.002
Suboptimal dosage of prophylactic antibiotic†	20 (43.5)	51 (22.5)	2.7 (1.4, 5.1)	0.003
Only cefazolin used as prophylactic antibiotic	24 (52)	168 (74)	0.4 (0.2, 0.7)	0.003
Aminoglycoside used as prophylactic antibiotic	17 (37)	41 (18)	2.7 (1.3, 5.3)	0.004
Intravenous steroids during operation	8 (17)	85 (37)	0.4 (0.2, 0.8)	0.009
Wound irrigated with antibiotic-containing solution	40 (87)	162 (71)	2.7 (1.1, 6.6)	0.028
No. of intervertebral levels				
1	10 (22)	83 (37)	1.0	
2-3	21 (46)	94 (41)	1.9 (0.8, 4.2)	0.135
4-6	7 (15)	30 (13)	1.9 (0.7, 5.5)	0.218
≥7	8 (17)	20 (9)	3.3 (1.2, 9.5)	0.025
Duration of operation >75th percentile†	18 (39)	49 (22)	2.4 (1.2, 4.6)	0.012
Hemovac drain placed	26 (56.5)	95 (42)	1.8 (1.0, 3.4)	0.068
Drains in place ≥3 days	33 (72)	108 (48)	2.8 (1.4, 5.6)	0.003
≥2 resident surgeons	32 (70)	109 (48)	2.5 (1.3, 4.9)	0.008

*Cefazolin given more than sixty minutes before the incision or after the incision, or another antibiotic given after the incision. Two hundred and twenty-nine (84%) of the 273 patients received prophylactic cefazolin, alone (192), in combination with an aminoglycoside (thirty-four), or in combination with another antibiotic (three). †One gram of cefazolin used as a prophylactic antibiotic in patients with a body mass index of ≥30.0 kg/m². ‡The 75th percentile for fusion was 310.5 minutes; the 75th percentile for non-fusion operations was 145 minutes.

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Postoperative Wound Infection Rates after Posterior Instrumented Spinal Surgery in Diabetic Patients

Jen-Chung Liao, MD; Wen-Jer Chen, MD; Lih-Huei Chen, MD; Chi-Chien Niu, MD

- Diabetes
- 337 Posterior lumbar fusions
- 39 diabetics – 4 had SSI
- 298 non diabetic – 2 had SSI

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TABLE 1. Rate of Infection Based on Patient Age and Primary Diagnosis*

Primary Diagnosis	No. Cases	Superficial Infection (%)	Deep Infection (%)	Total Infection (%)
Adult (≥21 yr)				
Degenerative disease	46,434	308 (0.7)	342 (0.7)	650 (1.4)
Scoliosis	5801	66 (1.1)	146 (2.5)	212 (3.7)
Spondylolisthesis	10,529	93 (0.9)	130 (1.2)	223 (2.1)
Fracture	6025	31 (0.5)	92 (1.5)	123 (2.0)
Kyphosis	2012	28 (1.4)	57 (2.8)	85 (4.2)
Other	11,089	113 (1.0)	237 (2.1)	350 (3.2)
Primary Tumor†	404	4 (1.0)	7 (1.7)	11 (2.7)
Metastatic Tumor†	726	9 (1.2)	27 (3.7)	36 (5.0)
Acute osteo/discitis†	866	12 (1.4)	32 (3.7)	44 (5.1)
Implant revision/removal†	1720	16 (0.9)	39 (2.3)	55 (3.2)
Not recorded	192	2 (1.0)	2 (1.0)	4 (2.1)
Total	82,082	641 (0.8)	1006 (1.2)	1647 (2.0)
Pediatric (<21 yr)				
Degenerative disease	654	5 (0.8)	1 (0.2)	6 (0.9)
Scoliosis	20,424	195 (1.0)	341 (1.7)	536 (2.6)
Spondylolisthesis	827	9 (1.1)	12 (1.5)	21 (2.5)
Fracture	623	5 (0.8)	9 (1.4)	14 (2.2)
Kyphosis	1555	35 (2.3)	49 (3.2)	84 (5.4)
Other	1273	11 (0.9)	23 (1.8)	34 (2.7)
Primary tumor†	152	0 (0.0)	5 (3.3)	5 (3.3)
Implant revision/removal†	308	1 (0.3)	6 (1.9)	7 (2.3)
Not recorded	76	1 (1.3)	1 (1.3)	2 (2.6)
Total	25,432	261 (1.0)	436 (1.7)	697 (2.7)

*Age not recorded for 905 patients. These patients are not included in this table.
†Selected subgroup within the "other" category. Note that numbers of cases for these subgroups are part of the total other cases indicated.

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TABLE 2. Rate of infection among adult patients with a primary diagnosis of degenerative disease, stratified based on spinal location and subtype of disease

Spinal Region/Diagnosis	No. Cases	Superficial Infection (%)	Deep Infection (%)	Total Infection (%)
Cervical				
Postlaminectomy syndrome	35	1 (2.9)	1 (2.9)	2 (5.7)
Spinal stenosis	3466	13 (0.4)	27 (0.8)	40 (1.2)
Spondylotic radiculopathy	1859	9 (0.5)	5 (0.3)	14 (0.8)
Degenerative disc disease	1769	5 (0.3)	7 (0.4)	12 (0.7)
Disc herniation	4472	11 (0.2)	12 (0.3)	23 (0.5)
Not recorded	73	0 (0.0)	0 (0.0)	0 (0.0)
Total	11,674	39 (0.3)	52 (0.4)	91 (0.8)
Thoracic				
Degenerative disc disease	95	0 (0.0)	3 (3.2)	3 (3.2)
Spinal stenosis	161	2 (1.2)	2 (1.2)	4 (2.5)
Disc herniation	235	3 (1.3)	1 (0.4)	4 (1.7)
Spondylotic radiculopathy	17	0 (0.0)	0 (0.0)	0 (0.0)
Not recorded	16	0 (0.0)	0 (0.0)	0 (0.0)
Total	524	5 (1.0)	6 (1.1)	11 (2.1)
Lumbar				
Spondylotic radiculopathy	949	22 (2.3)	14 (1.5)	36 (3.8)
Spinal stenosis	12,270	116 (0.9)	153 (1.2)	269 (2.2)
Postlaminectomy syndrome	573	6 (1.0)	4 (0.7)	10 (1.7)
Degenerative disc disease	7213	55 (0.8)	58 (0.8)	113 (1.6)
Disc herniation	12,694	62 (0.5)	51 (0.4)	113 (0.9)
Not recorded	211	2 (0.9)	2 (0.9)	4 (1.9)
Total	33,910	263 (0.8)	282 (0.8)	545 (1.6)
Spinal location not recorded	326	1 (0.3)	2 (0.6)	3 (0.9)

TABLE 3. Rate of Infection Among Patients with a Primary Diagnosis of Scoliosis, Stratified Based on Patient Age and Subtype of Scoliosis

Age Group/Type of Scoliosis	No. of Cases	Superficial Infection (%)	Deep Infection (%)	Total Infection (%)
Adult (≥21 yr)				
Neuromuscular	292	8 (2.7)	18 (6.2)	26 (8.9)
Posttraumatic	30	0 (0.0)	2 (6.7)	2 (6.7)
Degenerative	2533	31 (1.2)	73 (2.9)	104 (4.1)
Congenital	137	1 (0.7)	4 (2.9)	5 (3.6)
Idiopathic	2488	23 (0.9)	46 (1.8)	69 (2.8)
Other	139	3 (2.2)	2 (1.4)	5 (3.6)
Not recorded	182	0 (0.0)	1 (0.5)	1 (0.5)
Total	5801	66 (1.1)	146 (2.5)	212 (3.7)
Pediatric (<21 yr)				
Posttraumatic	35	1 (2.9)	1 (2.9)	2 (5.7)
Neuromuscular	4855	83 (1.7)	184 (3.8)	267 (5.5)
Congenital	2045	27 (1.3)	18 (0.9)	45 (2.2)
Idiopathic	11,741	65 (0.6)	100 (0.9)	165 (1.4)
Other	1464	16 (1.1)	31 (2.1)	47 (3.2)
Not recorded	284	3 (1.1)	7 (2.5)	10 (3.5)
Total	20,424	195 (1.0)	341 (1.7)	536 (2.6)

TABLE 4. Rate of Infection Among Patients with a Primary Diagnosis of Kyphosis, Stratified Based on Patient Age and Subtype of Kyphosis

Age Group/Type of Kyphosis	No. Cases	Superficial Infection (%)	Deep Infection (%)	Total Infection (%)
Adult (≥21 yr)				
Postlaminectomy	198	5 (2.5)	5 (2.5)	10 (5.1)
Osteoporosis	104	3 (2.9)	2 (1.9)	5 (4.8)
Scheuermann	227	2 (0.9)	8 (3.5)	10 (4.4)
Posttraumatic	365	3 (0.8)	12 (3.3)	15 (4.1)
Fixed sagittal plane deformity	553	6 (1.1)	15 (2.7)	21 (3.8)
Neuromuscular	42	0 (0.0)	1 (2.4)	1 (2.4)
Congenital	48	0 (0.0)	1 (2.1)	1 (2.1)
Other	396	9 (2.3)	13 (3.3)	22 (5.6)
Not recorded	79	0 (0.0)	0 (0.0)	0 (0.0)
Total	2012	28 (1.4)	57 (2.8)	85 (4.2)
Pediatric (<21 yr)				
Neuromuscular	264	10 (3.8)	27 (10.2)	37 (14.0)
Fixed sagittal plane deformity	18	1 (5.6)	0 (0.0)	1 (5.6)
Postlaminectomy	64	3 (4.7)	0 (0.0)	3 (4.7)
Scheuermann	634	12 (1.9)	15 (2.4)	27 (4.3)
Posttraumatic	31	1 (3.2)	0 (0.0)	1 (3.2)
Congenital	329	3 (0.9)	2 (0.6)	5 (1.5)
Other	200	4 (2.0)	5 (2.5)	9 (4.5)
Not recorded	15	1 (6.7)	0 (0.0)	1 (6.7)
Total	1555	35 (2.3)	49 (3.2)	84 (5.4)

TABLE 5. Summary of Surgical Characteristics Assessed for Association with Infection

Parameter	No. Cases	Superficial Infection (%)	Deep Infection (%)	Total Infection (%)	*P**
Spinal fusion performed					
Yes	72,534	642 (0.9)	1072 (1.5)	1714 (2.4)	<0.001
No	35,877	267 (0.7)	377 (1.1)	644 (1.8)	
Not recorded	8	0 (0.0)	0 (0.0)	0 (0.0)	
Type of fusion					
Post-ant-post	271	2 (0.7)	7 (2.6)	9 (3.3)	
Anterior-posterior	7887	91 (1.2)	161 (2.0)	252 (3.2)	<0.001†
Posterolateral	19,710	221 (1.1)	379 (1.9)	600 (3.0)	<0.001†
Interlaminar/facet	16,192	167 (1.0)	281 (1.7)	448 (2.8)	0.003†
All fusion cases	72,534	642 (0.9)	1072 (1.5)	1714 (2.4)	
TLIF/PLIF	12,267	104 (0.8)	182 (1.5)	286 (2.3)	
Anterior only	15,336	46 (0.3)	48 (0.3)	94 (0.6)	<0.001†
Not recorded	871	10 (1.1)	14 (1.6)	24 (2.8)	
Implants					
Yes	74,114	647 (0.9)	1092 (1.5)	1739 (2.3)	<0.001
No	34,305	262 (0.8)	357 (1.0)	619 (1.8)	
Revision surgery					
Yes	16,503	183 (1.1)	359 (2.2)	542 (3.3)	<0.001
No	91,916	726 (0.8)	1090 (1.2)	1816 (2.0)	
Minimally invasive approach					
Yes	14,301	43 (0.3)	35 (0.2)	78 (0.5)	<0.001
No	94,115	866 (0.9)	1414 (1.5)	2280 (2.4)	
Not recorded	3	0 (0.0)	0 (0.0)	0 (0.0)	

*P-values are based on statistical comparisons of total infection rates.
†Anterior-posterior, posterolateral, and interlaminar/facet fusions had significantly higher and anterior only had significantly lower rates of infection compared with the overall rate of infection for all fusion patients (2.4%).
TLIF indicates transforaminal lumbar interbody fusion; PLIF, posterior lumbar interbody fusion.

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