

2 evidence exists. Additionally, there is a lack of comparative studies directly looking at flap coverage versus traditional wound closure techniques.

REFERENCES

- [1] Koutsoumbelis S, Hughes AP, Girardi FP, Cammisa FP, Finerty EA, Nguyen JT, et al. Risk factors for postoperative infection following posterior lumbar instrumented arthrodesis. *J Bone Joint Surg Am.* 2011;93:1627-1633. doi:10.2106/JBJS.J.00039.
- [2] Chang DW, Friel MT, Youssef AA. Reconstructive strategies in soft tissue reconstruction after resection of spinal neoplasms. *Spine.* 2007;32:1101-1106. doi:10.1097/01.brs.0000261555.72265.3f.
- [3] Mitra A, Mitra A, Harlin S. Treatment of massive thoracolumbar wounds and vertebral osteomyelitis following scoliosis surgery. *Plast Reconstr Surg.* 2004;113:206-213. doi:10.1097/01.PRS.0000097440.15013.5C.
- [4] Eshima I, Mathes SJ, Paty P. Comparison of the intracellular bacterial killing activity of leukocytes in musculocutaneous and random-pattern flaps. *Plast Reconstr Surg.* 1990;86:541-547.
- [5] Murphy RC, Robson MC, Hegggers JP, Kadowaki M. The effect of microbial contamination on musculocutaneous and random flaps. *J Surg Res.* 1986;41:75-80.
- [6] Calderon W, Chang N, Mathes SJ. Comparison of the effect of bacterial inoculation in musculocutaneous and fasciocutaneous flaps. *Plast Reconstr Surg.* 1986;77:785-794.
- [7] Dumanian GA, Ondra SL, Liu J, Schafer MF, Chao JD. Muscle flap salvage of spine wounds with soft tissue defects or infection. *Spine.* 2003;28:1203-1211. doi:10.1097/01.BRS.0000067260.22943.48.
- [8] Chieng LO, Hubbard Z, Salgado CJ, Levi AD, Chim H. Reconstruction of open wounds as a complication of spinal surgery with flaps: a systematic review. *Neurosurg Focus.* 2015;39:E17. doi:10.3171/2015.7.FOCUS15245.



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QUESTION 3: What is the optimal irrigation solution (volume, type and frequency) during clean or infected spinal surgery cases?

RECOMMENDATION:

1. There is insufficient evidence to recommend for or against normal saline irrigation before closure for the purpose of preventing surgical site infection (SSI) in clean spinal surgery.
2. There is insufficient evidence to support recommendations for optimal volume, type and frequency of irrigation to prevent SSI in clean spinal surgery.
3. Consider the use of irrigation with an aqueous povidone-iodine solution before closure for the purpose of preventing SSI in clean spinal surgery.
4. There is insufficient evidence to recommend for or against chlorhexidine and antibiotic solution irrigation of incisional wounds for the purpose of preventing SSI in clean spinal surgery.
5. There is insufficient evidence to recommend a specific solution (volume, type and frequency) for irrigation in infected spinal surgery.

LEVEL OF EVIDENCE:

1. Consensus
2. Limited
3. Moderate
4. Consensus
5. Consensus

DELEGATE VOTE: Agree: 73%, Disagree: 7%, Abstain: 20% (Super Majority, Strong Consensus)

RATIONALE

1: Irrigation versus no irrigation

No randomized controlled trials (RCTs) or observational studies have compared incisional wound irrigation with normal saline versus no irrigation in clean spinal surgery.

One retrospective observational study evaluating 1,831 posterior lumbar interbody fusion (PLIF) procedures demonstrated a significantly higher risk of SSI with no local bone irrigation compared to those with local bone irrigation in multivariate analysis (odds ratio (OR): 5.248, $p = 0.001$) [1]. Two retrospective observational studies demonstrated no significant association between interbody irrigation with SSI compared with no interbody irrigation in those undergoing PLIF and lumbar microdiscectomy [1,2].

2: Optimal volume, type and frequency of irrigation for clean spinal surgery

No RCT has compared the amount of normal saline for irrigation to prevent SSI in spinal surgery. One observational study including 223 consecutive spinal operations in a single university

hospital demonstrated a significant association with prevention of SSI (OR 0.08, 95% confidence interval (CI) 0.01 to 0.61) with sufficient amount of saline (mean > 2,000 ml per hour compared with < 1,000 ml per hour) in a multivariate analysis [3].

No RCT or observational study has compared the frequency of irrigation to prevent SSI in spinal surgery.

A very low quality of evidence from two observational studies demonstrated a benefit of pulse pressure irrigation compared to bulb syringe irrigation with normal saline [4,5]. One study showed an advantage of decreasing wound contamination rate in PLIF surgical procedures (OR:6.35, $p = 0.046$) [4]. Another study showed significant decrease of postoperative infection by ten-fold (11% [28/261] vs. 0.7% [2/263], $p < 0.001$) by using pulsatile irrigation with vancomycin and ceftazidime prophylaxis for posterior spinal fusion surgeries in adolescent idiopathic scoliosis patients [5].

3 and 4: Optimal solution for clean spinal surgery

There is moderate-quality evidence from two RCTs and two observational studies that povidone iodine irrigation has a signifi-

cant benefit in reducing SSI risk in patients with primarily closed surgical incisions when compared to conventional normal saline wound irrigation [6–9]. In one RCT focusing on primary instrumented lumbosacral posterolateral fusion performed by the same surgeon, SSI was significantly lower in those who underwent 0.35% povidone-iodine irrigation compared with normal saline irrigation (0% [0/120] vs. 4.8% [6/124], $p = 0.029$), with no significant difference in fusion rate, wound healing, improvement of pain score, function score and ambulatory capacity [6].

In another RCT focusing on spinal surgery, SSI was significantly lower in those who underwent 0.35% povidone-iodine irrigation compared with normal saline irrigation (0% [0/208] vs. 3.4% [7/206], $p = 0.0072$) [7]. In one observational study comparing before and after the application of combination of 0.3% betadine irrigation with intra-wound vancomycin (VCM) powder (1 gm), the incidence of SSI significantly decreased after intervention (1.3% [15/1173] vs. 2.4% [30/1,252], $p = 0.042$) with a protective effect in multivariate analysis (OR 0.23, 95% CI: 0.06–0.86; $p = 0.0287$) [8]. In another observational study involving 950 spinal surgeries comparing before and after application of povidone-iodine and hydrogen peroxide solution irrigation, those irrigated with povidone-iodine and hydrogen peroxide solution were less likely to develop SSI compared with pre-intervention period (0% [0/490] vs. 1.5% [7/460]) [9].

No RCT or observational study has compared chlorhexidine or antibiotic solution irrigation to normal saline irrigation to prevent SSI in spinal surgery.

5: Optimal irrigation for infected spinal surgery

No RCT or observational study has compared incisional wound irrigation with no irrigation in infected spinal surgery.

REFERENCES

- [1] Kim JH, Ahn DK, Kim JW, Kim GW. Particular features of surgical site infection in posterior lumbar interbody fusion. *Clin Orthop Surg.* 2015;7:337–343. doi:10.4055/cios.2015.7.3.337.
- [2] Zhu RS, Ren YM, Yuan JJ, Cui ZJ, Wan J, Fan BY, et al. Does local lavage influence functional recovery during lumbar discectomy of disc herniation?: One year's systematic follow-up of 410 patients. *Medicine (Baltimore).* 2016;95:e5022. doi:10.1097/MD.0000000000005022.
- [3] Watanabe M, Sakai D, Matsuyama D, Yamamoto Y, Sato M, Mochida J. Risk factors for surgical site infection following spine surgery: efficacy of intraoperative saline irrigation. *J Neurosurg Spine.* 2010;12:540–546. doi:10.3171/2009.11.SPINE09308.
- [4] Ahn DK, Lee S, Moon SH, Kim DG, Hong SW, Shin WS. Bulb syringe and pulsed irrigation: which is more effective to remove bacteria in spine surgeries? *Clin Spine Surg.* 2016;29:34–37. doi:10.1097/BSD.000000000000068.
- [5] Myung KS, Glassman DM, Tolo VT, Skaggs DL. Simple steps to minimize spine infections in adolescent idiopathic scoliosis. *J Pediatr Orthop.* 2014;34:29–33. doi:10.1097/BPO.0b013e31829b2d75.
- [6] Chang FY, Chang MC, Wang ST, Yu WK, Liu CL, Chen TH. Can povidone-iodine solution be used safely in a spinal surgery? *Eur Spine J.* 2006;15:1005–1014. doi:10.1007/s00586-005-0975-6.
- [7] Cheng MT, Chang MC, Wang ST, Yu WK, Liu CL, Chen TH. Efficacy of dilute betadine solution irrigation in the prevention of postoperative infection of spinal surgery. *Spine.* 2005;30:1689–1693.
- [8] Tomov M, Mitsunaga L, Durbin-Johnson B, Nallur D, Roberto R. Reducing surgical site infection in spinal surgery with betadine irrigation and intrawound vancomycin powder. *Spine.* 2015;40:491–499. doi:10.1097/BRS.0000000000000789.
- [9] Ulivieri S, Toninelli S, Petrini C, Giorgio A, Oliveri G. Prevention of postoperative infections in spine surgery by wound irrigation with a solution of povidone-iodine and hydrogen peroxide. *Arch Orthop Trauma Surg.* 2011;131:1203–1206. doi:10.1007/s00402-011-1262-0.

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QUESTION 4: Is negative pressure wound therapy (NPWT) effective in the treatment of wounds that are left to heal by secondary intention?

RECOMMENDATION: There is no evidence that NPWT is superior to conventional standard dressing changes in the treatment of wounds that are left to heal by secondary intention.

LEVEL OF EVIDENCE: Limited

DELEGATE VOTE: Agree: 60%, Disagree: 20%, Abstain: 20% (Super Majority, Weak Consensus)

RATIONALE

Animal studies have shown that sub-atmospheric pressure improves the local wound environment through both direct and indirect effects. Sub-atmospheric pressure accelerates healing and reduces the time to wound closure and the incidence of wound infections [1,2]. NPWT removes interstitial fluid and improves lymphatic drainage and microvascular blood flow. It increases oxygen and nutrient delivery in the wound, facilitates removal of metabolic byproducts, increases granulation tissue formation and ultimately accelerates wound healing. Moreover, by isolating the wound from the surrounding environment, NPWT may reduce the colonization of the wound by bacteria and avoid superinfections, particularly in areas with high skin contamination rates such as the perineal and lower back spine area.

Predominantly observational studies, but also small trials (low quality of evidence), have suggested that rates of surgical site infection (SSI) may be lower if NPWT is used instead of conven-

tional wound dressings [3]. In a meta-analysis of six randomized control trials including a systematic review, it was observed that the risk of SSI was reduced when NPWT was used (odds ratio 0.56, 95% CI 0.32 to 0.96) in both clean and clean-contaminated procedures. However, results were no longer significant for orthopaedic/trauma surgery [3]. In a Cochrane meta-analysis that compared NPWT with other types of wound dressing for persistently-draining wounds in skin graft patients, in orthopaedic patients undergoing arthroplasty and general/trauma surgery patients it was concluded that there is no evidence for the effectiveness of NPWT on the complete healing of wounds expected to heal by primary intention [4]. An up-to date systematic review in trauma patients concluded that, based on available observational studies, NPWT [5] was safe and showed an efficacy comparable to standard dressings [6]. The primary clinical advantages of NPWT in the trauma population are its ease of application, decreased