RATIONALE

Following surgery, wounds are typically closed in a primary fashion. Alternative methods of wound closure include secondary closure and delayed primary closure. Secondary closure is when wounds are left to close naturally on their own. Delayed primary closure (DPC), a combination of secondary and primary closure, is when a wound is cleaned and left open until infection is controlled, followed by surgical closure of the wound. Delayed primary closure is only used on occasion, typically involving contaminated traumatic injuries.

In their prospective randomized study, Singh et al. found that patients undergoing delayed primary closure of contaminated abdominal wounds related to hollow viscus perforation had lower infection rates (17.5%) and shorter hospital stays (18.1 days) when compared to patients undergoing primary closure (42.5% infection and 20.7 days) [1]. Chiang et al. found a similar result for treatment of perforated appendicitis. Patients randomized to primary closure had an infection rate of 38.9% and an 8.4-day length of stay, while patients randomized to delayed primary closure had an infection rate of 2.9% and a 6.3-day length of stay [2].

DPC has also been shown to result in no long-term issues and not be associated with a higher incidence of complications in pediatric liver transplant recipients [3]. Orthopaedic surgeons are familiar with DPC in the context of fasciotomy wounds in patients with compartment syndrome when delayed primary closure is utilized [4,5].

There are, however, no high-level studies related to the role of DPC in spine surgery. In the absence of concrete evidence, and in borrowing from general surgery and other fields of orthopaedics, we feel that primary closure of a wound is the most preferred method of dealing with wound issues in spine patients. However, there may be circumstances when primary closure of the wound may not be possible or preferred. This may include patients with grossly contaminated traumatic wounds, patients with persistent wound drainage when attempts to address drainage have failed and in patients with severe soft tissue loss when primary closure is not possible.

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QUESTION 2: What is the indication for muscle advancement flaps in patients with spinal infections?

RECOMMENDATION: Muscle advancement flaps are useful to help close wounds with exposed hardware as well as those which fail local treatment/vacuum-assisted closure (VAC) therapy and to help improve infection eradication.

LEVEL OF EVIDENCE: Consensus

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

RATIONALE

Multiple risk factors exist for wound complications following spinal surgery, including diabetes, chronic obstructive pulmonary disease, resection of neoplasm with excision of significant soft tissue and prior radiation. Additionally, infection is often complicated by loss of soft tissue and poor tissue viability, which leads to an inability to close the wound overall, resulting in exposed hardware [1,2].

Even if the wound is able to be closed primarily or following VAC therapy, it is important to recognize that the same factors that led to the infection and wound breakdown in the first place still exist [3]. To that end, local or vascularized muscle flaps provide multiple advantages over simple wound closure or delayed primary closure. Muscle flaps have been shown to increase blood flow and oxygen delivery, and decrease bacterial load [4–6].

It seems rational that wounds that are completely unable to be closed due to large soft tissue defects with exposed hardware or wounds that fail to close following VAC therapy are reasonable indications for flap coverage. But, the absolute indication for flap coverage following wound debridement in an otherwise closeable wound remains unclear. Multiple authors argue that it remains a reasonable option versus irrigation and debridement with immediate or delayed primary closure.

Dumanian et al. reviewed their experience with flap coverage for spinal wounds [7]. Fifteen patients in their group had postoperative wound dehiscence or infection, with 12 patients having exposed hardware. They were treated with either immediate local flap coverage or two to three days of dressing changes followed by flap coverage. Of the surviving 14 patients, 13 had healed wounds at final follow-up, and none required hardware removal. One patient on chronic steroids/immunosuppression had persistent infection treated with chronic suppressive antibiotics.

Chieng et al. performed a systematic review on the use of flaps for management of wound complications [8]. While several case reports and retrospective series present supportive data, the authors note that relying on the data is difficult as no level 1 or level

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

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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-