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Review Article

# Preoperative measures to prevent/minimize risk of surgical site infection in spinal surgery

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Received: 28 October 18 Accepted: 29 October 18 Published: 11 December 18

## Abstract

**Background:** Multiple measures prior to spine surgery may reduce the risks of postoperative surgical site infections (SSIs).

**Methods:** The incidence of SSI following spinal surgery (including reoperations and readmissions) may be markedly reduced by performing less extensive procedures and avoiding fusion where feasible. Preoperative testing up to 3 weeks postoperatively should include other studies to limit the perioperative SSI risk; cardiac stress tests (e.g., older patients/cardiac comorbidities), starting tamsulosin in males over 60 (e.g. avoid urinary retention due to benign prostatic hypertrophy), albumin/prealbumin levels (e.g., low levels increase SSI risk), and HBA1C levels to identify new/treat known diabetics (normalize/reduce preoperative levels).

**Results:** Other measures include the timely administration of preoperative antibiotics (e.g., cefazolin 2 g nonpenicillin allergic), one dose of gentamicin (adjusted dose/weight), nasal cultures for methicillin-resistant *Staphylococcus aureus* (patients/health-care workers), and bathing 2 weeks preoperatively with chlorhexidine gluconate 4% (not just night before/morning of surgery). Additionally, prior to surgery, the following medications that increase the bleeding risk should be stopped (e.g. for varying periods); anticoagulants, antiplatelet therapies (e.g., aspirin for at least 7–10 days), nonsteroidal anti-inflammatories (NSAIDS: timing depends on the drug), vitamin E, and herbal supplements. Additionally, avoiding elective spinal surgery in morbidly obese patients and recognizing other major medical contraindications to spinal surgery should help reduce infection, morbidity, and mortality rates.

**Conclusions:** Appropriate preoperative and intraoperative prophylactic maneuvers may reduce the risk of postoperative spinal SSI. Specific attention to these details may avoid infections and improve outcomes.

**Key Words:** Chlorhexidine gluconate washes, preoperative measures, prevention, prophylactic antibiotics, spinal surgery, stop NSAIDS and aspirin, surgical site infections

**Access this article online**

**Website:** www.surgicalneurologyint.com

**DOI:** 10.4103/sni.sni_372_18

**Quick Response Code:**



**How to cite this article:** Epstein NE. Preoperative measures to prevent/minimize risk of surgical site infection in spinal surgery. Surg Neurol Int 2018;9:251. http://surgicalneurologyint.com/Preoperative-measures-to-prevent/minimize-risk-of-surgical-site-infection-in-spinal-surgery/

## INTRODUCTION

### Incidence of surgical site infections

Surgical site infections (SSIs) following spinal surgery constitute a major health risk. The incidence of these infections ranges from 0%, 0.7%, 1.9%, 4.4% up to 10%. Postoperative spinal infections/SSI were typically dependent on the following variables; severity of disease, number of levels involved, presence/duration of postoperative drains used, prior hospitalization, duration of preoperative/postoperative stay, duration of surgery, number of transfusions, and number of surgeons.[1,10,11,15,31,33,37] In Shillingford *et al.*, the rate of SSI after scoliosis surgery (Scoliosis Research Society Morbidity/Mortality database) ranged from 1.9% to 4.4%.[37] Out of 47,755 procedures from 2012, 578 (1.2%) had SSIs. Spinal fusions constituted 86.3% of these cases, and 75.1% were posterior procedures. Deep infections occurred 68.0% of the time and were predominantly attributed to methicillin-sensitive (41.9%) or methicillin-resistant (17.0%) organisms. In Park *et al.*, the incidence of SSI in spine surgery varied from 0.7% to 10%, with higher frequencies for those with significant medical comorbidities.[31] In Pull ter Gunne *et al.*, 3174 patients (1996–2005) exhibited 132 (4.15%) SSI; 84 were deep, and 48 were superficial.[33] In Epstein's series (2007), the incidence of postoperative SSI following lumbar-instrumented fusions was 0/106 using the Silverlon Dressings for 2 postoperative weeks versus 3 (2.3%) for 128 similar cases previously performed using routine postoperative dressings.[10]

### Decompression alone reduced risk of SSI versus TLIF/MI TLIF fusions

The incidence of postoperative spinal SSI highly correlated with more extensive surgery, longer surgical procedures, and the use of instrumentation. In 2018, Epstein (2018) evaluated 137 patients undergoing 2–3 level (58 patients) and 4–6 level (79 patients) laminectomies for disk disease, multilevel stenosis, and/or degenerative spondylolisthesis (26/79 in the latter group).[15] There were no infections (no SSI) and lower complication/reoperation rates when compared to the literature on transforaminal lumbar interbody fusions (TLIF) (open/minimally invasive [MI]). In Epstein's series, at 2 postoperative years, there were no new postoperative neurological deficits, no infections, no reoperation for adjacent segment disease, four (2.9%) instances of intraoperative cerebrospinal fluid fistulas (e.g. primarily repaired without recurrence), no readmissions, and just one reoperation (postoperative day 7) for a sterile seroma. These rates compared favorably versus those in the literature for TLIF/MI TLIF. Further, the literature demonstrated that at 2 postoperative years, the complication rate was 4.8% for laminectomy alone versus 8.3% for decompressions with TLIF/MI TLIF. At 5 postoperative years, the respective rates were 10.6% for laminectomy alone versus 18.4% for TLIF/MI TLIF. Furthermore, the MI TLIF, complication rates ranged from 7.7% to 23.0% and included 8.3% SSI, 6.1% durotomies, 9.7% permanent neurological deficits, and 20.2% new sensory deficits. Additionally, indications for reoperations (1.6–6%) for MI TLIF/TLIF included instrumentation failure (2.3%), cage migration (1.26–2.4%), cage extrusions (0.8%), and misplaced screws (1.6%). Notably, hospital costs for TLIF/MI TLIF lumbar fusions were also 2.6 greater versus laminectomy alone.

### Previously published measures to reduce risk of SSI in spine surgery

Multiple preoperative recommendations for antibiotic prophylaxis and other measures to avoid SSI following spinal surgery include (1) nasal cultures and Bactroban ointment (mupirocin) to reduce risk of methicillin-resistant *Staphylococcus aureus* (MRSA) and (2) different regimens including 2 preoperative weeks of bathing with chlorhexidine gluconate (CHG) 4% to the skin.[11] In 2011, Epstein evaluated multiple preoperative, intraoperative, and postoperative measures to decrease the 0.4–3.5% incidence of spine surgery-related SSI reported in the literature. Preoperative prophylaxis against MRSA could utilize; (1) nasal cultures and Bactroban ointment (mupirocin), and (2) the preoperative application of CHG 4% to the skin (e.g. recommendation for bathing 2 preoperative weeks with CHG not just night before/morning of spinal surgery). Additional measures included copious intraoperative irrigation [normal saline (NS) and/or NS with polymyxin-B sulfate] every 15 min, utilizing instrumentation coated with antibiotics, and/or topically applying antibiotics (e.g., vancomycin powder). Further recommendations were the postoperative application of silver dressings ($AgNO_{(3)}$-impregnated dressings – Silverlon Dressings) for up to 1 month postoperatively, and continuing to bathe with CHG 4% around the wound.[10,11]

### Preoperative nasal swab cultures for methicillin resistant *S. aureus* in patients and health-care workers

Some studies have utilized preoperative nasal swab cultures obtained from patients and health-care workers (HCWs) to establish whether there is local colonization with MRSA prior to spine surgery to help avert postoperative infections. In Part I and II study of Mehta *et al.*, patients had intranasal swab cultures performed 3 weeks prior to surgery screening for MRSA; if positive, they were also followed for 4 postoperative weeks.[26] Part 1 MRSA-positive patients had to apply 2% mupirocin twice a day for 2, 3, or 5 days; they were recultured up to 4 weeks postoperatively. In Part II, all 60 patients only received

5 days of mupirocin twice a day (10 doses) and again were cultured for up to 4 postoperative weeks. Notably, 89.5% of all patients treated with 10 doses (5 days) of mupirocin (parts I and II) remained MRSA negative at 4 postoperative weeks, whereas just 68% of those receiving 6 doses remained MRSA culture negative. Joachim *et al*. then assessed the incidence of intranasal MRSA in 379 HCWs.[18] Of these, 157 (41.4%) had nasal cultures positive for *S. aureus*; 59 (37.6%) were MRSA positive, and nurses comprised 35 (45.5%) of those with MRSA. They highly recommended routine MRSA screening of HCW to help to reduce the spread of MRSA.

## Bathing with chlorhexidine gluconate 4% for 2 weeks before spine surgery to reduce SSI

To reduce the number of bacteria on the skin, the standard present recommendation is to bathe with CHG 4% the night before and the morning of spine surgery. We have trialed a more prolonged preoperative protocol using CHG 4% for 2 weeks before spine surgery; in our recent series of 137 patients undergoing laminectomies alone, there were no reported infections.[15]

Additionally, CHG 4% washes should be continued postoperatively, as studies have shown it takes just 72 h for other unwanted flora to reappear. Johnson *et al*. evaluated how CHG 4% bathing changed the flora for neonates in a neonatal intensive care unit (NICU) setting.[19] They cultured bacteria from the arm and groin skin for 18 CHG-exposed (2% CHG baths) and 22 nonexposed neonates; they found that the "bacterial burden" decreased following the first bath, but flora reappeared within 72 h. They concluded that bathing twice a week did not sufficiently control the skin flora and opted to increase its frequency. These findings can be applied to patients following spinal surgery, leading to the recommendation to continue postoperative daily baths with CHG 4%. Reynolds *et al*. further documented the efficacy of daily baths with CHG to reduce hospital-"acquired central line-associated bloodstream infections."[34]

## Preoperative and postoperative prophylactic antibiotic regimens

*Recommendations: Preoperative gentamicin (one dose) reduces risk of MRSA*

Many would recommend using gentamicin as a single preoperative dose (weight/adjusted) to limit the risk of postoperative MRSA. Dubrovskaya *et al*. evaluated the safety/efficacy of utilizing one preoperative prophylactic dose of gentamicin (4.5 mg/kg, adjusted for age, weight, and creatinine clearance) for spine, hip, and knee surgery (2011–2013), paying particular attention to nephrotoxicity.[8] There were $N = 1590$ patients in the gentamicin group: hip = 926, spine = 600, knee = 64 versus 2587 not treated with gentamicin. Nephrotoxicity occurred at comparable rates for both groups; 2.5% in gentamicin group and 1.8% in the control group. The authors concluded that "single high dose gentamicin is a safe and acceptable option for perioperative prophylaxis in eligible patients undergoing orthopedic surgeries." To avoid MRSA in spine surgery, Park *et al*. utilized cefazolin IV (standard) in 524 cases (48.8%), gentamicin IV in 526 cases (49.0%), and vancomycin powder in 72.3% cases.[31] Spinal surgery addressed cervical myelopathy (27.9%), lumbar stenosis (16.2%), lumbar spondylolisthesis (14.0%), and scoliosis (13.7%). Four (0.37%) SSI infections occurred in the gentamicin group also using vancomycin powder (3 deep and 1 superficial) versus 11 (1.23%) in the 892 control patients (cefazolin alone).

## Prophylactic cefazolin, vancomycin, and vancomycin powder regimens reduce risks of SSI in spine surgery

*Cefazolin prophylaxis and other regimens*

Preoperative antibiotic prophylaxis for spine surgery in nonpenicillin allergic patients is typically cefazolin 2 g IV, preferably administered within 15 min of the surgical incision. Those who are penicillin allergic, usually receive vancomycin 1 g IV SS (adjusted for age/other factors) over 1 h preoperatively (to avoid red man syndrome). In their series of 960 spinal cases, Park *et al*. evaluated the impact of adding vancomycin/gentamicin and/or vancomycin powder (2013–2016) to reduce the risks of MRSA; patients received intravenous cefazolin IV (48.8% of cases), gentamicin IV (49.0% of cases), and/or vancomycin powder (72.3% of cases).[31] Of these, 114 patients required revision spinal procedures (10.6%), and 4 SSIs (0.37%) occurred in the treatment group versus 11 who received cefazolin alone.

## Comparable efficacy of different regimens for postoperative cefazolin therapy

*Equal results for cefazolin 24 versus 72 h, or 2 doses versus until drains were removed*

Different postoperative regimens of prophylaxis with cefazolin have shown comparable efficacy of 24 versus 72 h dosing or two postoperative doses versus continuing the antibiotics until the drains were removed. In 2016, Marimuthu *et al*. compared the incidence of postoperative SSI using cefazolin for preoperative prophylaxis plus postoperatively continuing it for 24 versus 72 h.[25] Cefazolin was administered to 156 patients in the 72-h antibiotic group (group A) versus 170 patients in the 24-h group (group B). Results were comparable, showing an overall 1.8% rate of SSI. Abdul-Jabbar *et al*. used the Centers for Disease Control National Health Safety Network criteria to evaluate 7529 spine operations (performed 2005–2010); they identified 239 SSI.[1] Pathogens included *S. aureus* (45.2%), or *Staphylococcus epidermidis* (31.4%), whereas gram-negative organisms were found in 30.5%

of the patients. Methicillin resistance was observed in 34.3% of SSIs. Following adolescent idiopathic scoliosis surgery, Kamath *et al*. reviewed the efficacy of just 2 doses of postoperative antibiotics in 155 patients versus continuing antibiotics until drains were removed in 71 patients.[20] Postoperatively, SSI was found in 1.9% of patients receiving two doses versus 1.4% with antibiotics continued until drains were removed. They concluded cefazolin was safe/effective for prophylaxis against SSI using either regimen.

## Preoperative medical clearance should be obtained up to 3 weeks preoperatively

There are multiple reasons to obtain preoperative medical clearance up to 3 weeks preoperatively, particularly in patients over the age of 60 and/or with significant comorbidities (hypertension, diabetes, pulmonary disease, cardiac surgery–bypass–stents, peripheral vascular disease, other). This provides time to address uncontrolled hypertension, diabetes, asthma, and other medical issues. Shaydakov and Tuma (2018) underscored the need to minimize operative risk and maximize surgical safety by obtaining early/adequate preoperative surgical evaluation and testing.[36] This helps select patients for spinal surgery on a medical basis, as many spinal surgeons confine themselves to technical surgical considerations. High-risk patients who are not appropriate surgical candidates may be "screened out," avoiding prolonged hospital stays, SSI, and greater morbidity/mortality. They stated: "… estimation of an individual risk/benefit ratio for a specific surgical procedure can help to more objectively adopt non operative management strategy or select the best surgical procedure at the most appropriate point of time."

## Controversy over the "value-added" of preoperative cardiac stress testing

The need for ordering preoperative cardiac stress testing is increasingly falling upon the operating spinal surgeon, as often internists/cardiologists are unaware of he significant surgical risks. Valle *et al*. utilized preoperative stress tests to assess risks for postoperative adverse events following noncardiac surgery.[39] Out of 29,937 patients at 131 VA facilities, preoperative stress testing was performed in 13.2% of patients; 30-day postoperative major adverse events occurred in 4.0% (IQR 2.4–5.4%) of patients. They concluded that performing more preoperative stress testing did not yield better outcomes. Alternatively, Levett *et al*. found that preoperative cardiac stress testing was useful, as it specifically allowed surgeons to determine whether patients were appropriate surgical candidates, and could forecast what type of postoperative care patients would require (e.g., ICU/other).[24]

## Value of preoperative HBA1C testing for diabetes prior to spine surgery

For many patients, elevated Hemaglobin A1C (HbA1c) and prediabetes/diabetes are newly diagnosed at preoperative testing. With routine HBA1C screening, however, diabetes should be more readily diagnosed and appropriately treated (e.g. particularly to reduce HBA1C levels) prior to spinal surgery. Underwood *et al*. documented the value of routine preoperative HBA1C testing to document whether diabetics were sufficiently controlled to undergo surgery (e.g. HBA1C levels <8).[38] In 2013–2014, they tested HBA1C levels in 1236 out of 1334 (93%) patients with diabetes; for 228 patients, levels were ≥8 and, therefore, were considered high risk for SSI. Using the American Association of Clinical Endocrinologists/American Diabetes Association guidelines, anesthesia, surgeons, and preoperative nurse practitioners working together lowered preoperative HBA1C and blood glucose levels so that patients could then more safely undergo spinal surgery.

### *Diabetes increases SSI risk with spinal surgery*

There are more risks/complications in diabetics undergoing spine surgery, and the more poorly controlled the diabetes, the greater the risk of perioperative SSI and other adverse events. In 2017, Epstein reviewed the greater perioperative risks for adverse events, longer hospital stay, increased 30-day readmission/reoperation rates, and higher infection rates for diabetics undergoing spinal surgery.[13] Notably, diabetics were divided into several groups; insulin-dependent diabetes and noninsulin-dependent diabetes NIDD, and also uncontrolled versus controlled diabetics. Evaluating a study involving the Nationwide Inpatient Sample 1988–2003, data involving 197,461 lumbar fusions revealed 11,000 (5.6%) patients had diabetes. They exhibited; higher infection rates, greater transfusion requirements, more instances of pneumonias, more in-hospital mortalities, increased costs, and longer length of stay (LOS).

### *Diabetes reduces fusion rate*

Surgeons may also alter their operative decisions, particularly regarding fusions, as diabetics classically have higher pseudarthrosis rates. Moazzeni *et al*. evaluated 48 patients with versus 48 patients without diabetes undergoing lumbar fusions.[27] They studied multiple diabetes-related variables: duration of diabetes, fasting blood sugar levels, HBA1C levels, insulin dependence, operative time, transfusions along with other comorbidities. The fusion rate at 1 postoperative year was 78% for nondiabetics versus 53% for those with diabetes; the diabetics also exhibited poorer outcomes (e.g., using the Oswestry Disability Index [ODI] scale).

## Males over 60 should take alpha-blockers (e.g. Tamsulosin) to avoid postoperative urinary retention

In males over 60 years of age undergoing spine surgery, many urologists have recommended starting tamsulosin or other alpha-blockers preoperatively to reduce the risk of postoperative urinary retention (POUR). This

applies both to those with known benign prostatic hypertrophy (BPH) and those without such a prior diagnosis. To support this position, one can look at the review by Roadman *et al*. who found the incidence of POUR for patients undergoing laparoscopic (e.g., total extraperitoneal) repairs of inguinal hernias ranged from 2% to 30%.[35] POUR can result in; greater length of stay, reduced satisfaction, and higher health-care costs. Here, the authors reviewed data from 2009 to 2016 involving 578 patients who underwent laparoscopic inguinal hernia repairs; 64 (11.1%) exhibited POUR. This correlated with "benign prostatic hyperplasia (BPH) age 60 years or older, urinary tract infection within 30 days, and decreased body mass index." The typical treatment for BPH according to Lepor included a variety of alpha-blockers; terazosin, doxazosin, tamsulosin, and alfuzosin.[23] These medications were typically readily tolerated with minimal adverse events, and tamsulosin and Alfuzosin SR did not warrant dose assessment/follow-up.

## Preoperative urine cultures/timing of antibiotic treatment

Preoperative testing includes a urinalysis, and in select cases, urine cultures. Obtaining these studies several weeks preoperatively allows for the appropriate therapy; one must differentiate between asymptomatic bacteriuria (ASB) versus urinary tract infection (UTI) before starting antibiotic therapy. How long should antibiotics be administered for UTIs prior to spine surgery to avoid SSI? Some would advocate 3–5 days or longer. However, Detweiler *et al*. noted that ASB and UTI are commonly found in older patients, and noted that many studies demonstrated no increased morbidity for not treating ASB with antibiotics.[7]

*Indications not to treat bacteriuria in neurosurgical trauma patients*

Belton *et al*. reviewed the results of "empiric treatment of urinary tract colonized patients who had sustained spinal cord injuries" and also evaluated the frequency of antibiotic-related *Clostridium difficile*, and the attendant mortality.[3] Out of 3563 neurosurgical trauma patients (followed 8 years: 1524 cranial, 1778 spinal, and 261 combined), 991 had neurosurgical procedures. Abnormal urinalyses typically resulted in antibiotic treatment. However, "empiric antibiotics" did not decrease the incidence of SSI/wound infections, but significantly raised the rate of *C. difficile* infection and *C. difficile*-related mortality rates.

## Low preoperative albumin/prealbumin levels increase risk of SSI with spine surgery

Normal protein levels (albumin/prealbumin) correlate with a reduced SSI risk for patients undergoing spine surgery, whereas low levels correlate with higher SSI risks. The diagnosis of malnutrition was based on albumin levels of less than 3.5 g/dL. If preoperative testing were to be performed at least 3 weeks preoperatively, then these low levels may be supplemented and restested. If low levels persisted, elective surgery may appropriately be delayed to reduce the risk of SSI. In Kudo *et al*., the authors correlated early-stage SSI with preoperative serum protein levels.[22] They noted that transferrin, prealbumin, and retinol-binding protein, so-called rapid turnover proteins (RTPs), may be the better indicators for early detection of nutritional deficits. Here, the authors correlated preoperative serum RTP levels with the incidence of postoperative spinal SSI. They evaluated 105 patients, averaging 64.4 years of age, undergoing spine surgery (2014–2015). The following variables were assessed: preoperative total lymphocyte count, serum albumin, transferrin, prealbumin, retinol-binding protein, pre- and postoperative C-reactive protein (CRP), white blood cell count, total lymphocyte count, etc. Antibiotic prophylaxis included a cephalosporin (second generation) unless the patient was penicillin allergic. They determined that 35 patients had increased serial CRP levels 3 or 4 days postoperatively, and were suspects for SSI. Other risk factors for SSI included; longer operative time, lower preoperative total lymphocyte count, and lower serum albumin/prealbumin levels. Adogwa *et al*. correlated the preoperative nutritional status with 30-day readmissions rates for patients undergoing nonemergent spine surgery.[2] For 145 patients having elective spinal procedures, preoperative serum albumin levels were evaluated; <3.5 g/dL was consistent with malnutrition, and also correlated with other comorbidities (e.g. postoperative complication rates, and 30-day readmission rates). Low albumin was observed in 28% of patients who were considered more susceptible to postoperative complications, and longer LOS (3.80 vs. 8.67 days). Of interest, 14.48% of patients were readmitted within 30 days, and malnourished patients were 3× more likely to be readmitted (malnourished: 27.50% vs. nourished: 9.52%).

## Preoperative checking for cessation of smoking which increases spine-related SSI

Multiple studies confirm that smoking status increases the risk of SSI and pseudarthrosis, particularly with interbody devices. Pesenti *et al*. utilized a meta-analysis to determine the risk factors for SSI following single/multilevel thoracolumbar anterior/posterior/circumferential spinal fusions.[32] They found 29 manuscripts involving 374,488 patients were adequate for inclusion in the study. The most prominent risk factors (5 of 12) for SSI included; obesity, diabetes, preoperative american society of anesthesiologists (ASA) score, tobacco use, and revision status. Echt *et al*. also assessed the impact of smoking on SSI/wound complications (superficial/deep/other) at 1 postoperative month for 1688 patients (e.g., identified by the American College of Surgeons National Surgical Quality Improvement Program database 2012–2014).[9] Spine operations included one-level posterolateral and

interbody fusions for degenerative spondylolisthesis. They identified 271 smokers (16.1%) undergoing interbody fusions who demonstrated a higher incidence of wound complications.

## Guidelines for cessation of anticoagulation prior to spine surgery

*When to stop anticoagulation prior to spine surgery*

For patients with significant cardiovascular disease requiring anticoagulation, the question is when to stop therapy prior to spine surgery. Narouze *et al*. noted that intravenous heparin should be stopped 4 h before surgery.[28] Subcutaneous heparin, whether given bid or tid, should be stopped 8–10 h preoperatively. Low-molecular weight heparin should be stopped 24 h prior to surgery, whereas fibrinolytic medications should be discontinued a minimum of 48 h preoperatively.[28] Alternatively, coumadin should be withheld for a minimum of 5 preoperative days.

## When to stop aspirin prior to spine surgery

*Risk of ASA withdrawal syndrome*

There are varied recommendations as to whether and when to stop aspirin therapy prior to spinal surgery. Gerstein *et al*. noted that acutely stopping ASA perioperatively risks the aspirin withdrawal syndrome defined by platelet revound, and an acute prothrombotic/hypercoagulable state that increases the risks of acute cardiovascular adverse events.[16] Nevertheless, they quoted that "standard practice" was to stop ASA before elective procedures/surgery because of the risk of perioperative bleeding particularly for intracranial, middle ear, posterior eye, intramedullary spine, and possibly transurethral prostatectomy surgery. To this, I would strongly recommend adding all spinal surgery.

For interventional spine procedures, Narouze *et al*. defined different parameters for stopping ASA.[28] They noted that uncoated ASA was absorbed within 30 min and fully effective within 1 h (>90% reduced thromboxane levels), whereas for coated ASA, full effectiveness may require 3–4 h. ASA irreversibly inactivated COX-1, thus blocking thromboxane production, platelet aggregation, and thrombosis. They confirmed an average of 7–10-day duration of platelet function, which meant that approximately 50% of platelet function returned within 5 days of stopping ASA.

## Recommendation: Stop ASA >7–10 days prior to spine surgery

Park *et al*. documented that cessation of aspirin from >7 to 10 days (theoretical 10 days for platelets to regenerate) prior to spine surgery resulted in no increased bleeding risk (comparable to no ASA), whereas stopping ASA 3–7 days preoperatively was not sufficient (increased bleeding).[29] They also observed that the normal time for platelets to regenerate was 7–10 days. In their series, they evaluated 86/182 cases of 1–2 level lumbar fusions performed in patients who used ASA; group 1 stopped ASA 3–7 days before surgery, whereas 2 group patients discontinued ASA >7–10 days before surgery. The control group consisted of 96 patients on no ASA. Group 1 patients stopping ASA 3–7 days preoperatively demonstrated more postoperative drainage and longer duration of drainage versus those in the control group or in group 2 (7–10 days cessation of ASA).

*Is stopping ASA 7-10 days preoperatively enough?*

Although platelets theoretically regenerate in 10 days, many older patients may require longer; I often recommend 3 weeks if possible. Kang *et al*. documented that low-dose ASA resulted in greater perioperative blood loss for patients (average age 68.5) having spinal fusions (average two segments) for degenerative disease.[21] They, therefore, recommended stopping low-dose ASA 7 days preoperatively. In their study, group I of 38 patients stopped 100 mg aspirin (average 40.3 months follow-up) at least 7 days preoperatively (mean, 9.0 days) versus the control group of 38 patients not on any aspirin. The intraoperative estimated blood loss (EBL) was similar for both groups (EBL average 855.2 $cm^3$ ASA group vs. 840.8 $cm^3$ control group no ASA). However, those previously on ASA had significantly greater postoperative blood drainage (averaging 864.4 $cm^3$) versus a much lower 458.4 $cm^3$ postoperative blood loss for control patients ($P < 0.001$). As anticipated, higher transfusion requirements and more bleeding complications occurred in the previous aspirin-treated group.

## Cessation of dipyridamole (persantine) preoperatively

Dipyridamole may be used in conjunction with ASA or alone as an antiplatelet aggregant that inhibits fibrin formation/accumulation, inhibits platelet function, and increases vasodilation.[28] Its half-life is just 13.6 h. It is typically recommended that this be stopped, and other anti-platelet aggregant medications be stopped for at least five or more half-lives prior to spine surgery.

## When to stop nonsteroidal anti-inflammatories (NSAIDs) prior to spine surgery

In Narouze *et al*., guidelines for when to stop nonsteroidal anti-inflammatories (NSAIDSs) were documented on the basis of the different half-lives of the various medications.[28] NSAIDS that could be stopped prior to interventional spine procedures for 1 day included diclofenac, ibuprofen, and ketorolac (Toradol). Two-day cessation of medication was recommended for etodolac and indomethacin. Four-day cessation prior to interventional spine procedures (e.g., epidurals, etc.) included meloxicam and naproxen. Six days were

recommended for stopping nabumetone, and 10 days for oxaprozing and prioxicam.

*NSAIDs increased bleeding risks in spine surgery*

NSAIDs increased bleeding risks for spine surgery and, therefore, should be discontinued for about five half-lives or longer prior to surgery.[28] Park *et al*. compared blood loss for not only those using ASA in lumbar fusion patients but also for those on NSAIDS.[30] They looked at 106 patients having 2 or more lumbar levels fused; there were 3 groups. Prior to spinal fusion surgery, group 1 was on no ASA, but on NSAIDS, group 2 discontinued ASA/NSAIDs at 1 week, and group 3 continued ASA/NSAIDs. NSAIDs used for groups 2 (stopped ASA/NSAIDs) and Group 3 patients (continued ASA/NSAIDs) resulted in significantly greater blood loss versus group 1 patients (on no ASA but on NSAIDs). Furthermore, platelet dysfunction was greater for group 2 versus 1, and group 3 versus versus 1 patients. The authors concluded that ASA resulted in significantly higher bleeding risks, even if ASA was stopped 1 week preoperatively. Notably, NSAIDs also increased surgical blood loss, and should be stopped preoperatively to reduce the risk of perioperative hemorrhage.

## Avoidance of vitamin E, herbal supplements, and foods that inhibit coagulation

Vitamin E (nuts, multivitamins), fish oils, and other herbal supplements may increase perioperative bleeding risks and should, therefore, be stopped prior to spinal surgery. Chang and Whitaker[6] observed that vitamin E and herbal medicines (*Ginkgo biloba*, garlic, ginger, ginseng, and feverfew) may increase bleeding following dermatological surgical procedures. Hodges and Kam[17] added other herbals/foods that increased the risk of bleeding, and, therefore, should be avoided up to 2 weeks preoperatively. These included echinacea, garlic, ginkgo biloba, ginseng, St. John's Wort, valerian, ephedra, kava, grapefruit juice, and ginger.

*Fish oils: Inhibition of bleeding with other anticoagulants but not alone*

Fish oils alone do not appear to increase perioperative bleeding risk, unless combined with other anticoagulants in which case they may potentiate hemorrhages. Carr[4] observed that omega-3 fatty acids were commonly taken, and assessed their risk of contributing to coagulation deficits. Fish oils inhibit "platelet-to-platelet" adhesion, and "platelet-stimulated thrombin generation." Although it has no impact on bleeding when used alone, it does increase the bleeding risk when combined with antiplatelet therapy, and/or factor Xa inhibitors (Xarelto, Eliquis) as well as warfarin.

## Avoiding elective spine surgery in patients with morbid obesity

One should avoid, where feasible, elective spinal surgery in patients who are morbidly obese as this markedly increases their perioperative risks of SSI, severe morbidity, and mortality. In Epstein's[14] review, "More risks and complications for elective spine surgery in morbidly obese patients," there were two standard definitions of morbid obesity; body mass index (BMI) equal to/greater than 35 plus two major comorbidities (e.g. hypertension, diabetes, etc.) or a BMI (morbidly obese III) of ≥40 kg/m$^2$. Perioperative enhanced risks included infection (e.g., wound seromas/hematomas), more wrong-level surgery (e.g., difficulty with intraoperative radiographic localization), a higher incidence of deep venous thrombosis/pulmonary embolism, more pneumonias, increased cardiac complications, blindness in the prone position, brachial and lumbar plexus injuries, and anesthetic risks. Here, one should initially recommend stringent major weight loss strategies.

## Avoiding elective spine surgery in patients with other major comorbidities

In a 2012 paper, Epstein asked: How much medicine do spine surgeons need to know to better select and care for patients?[12] Certainly spinal surgeons need to "cross -talk" with patients' medical physicians to identify/highlight major medical comorbidities that may preclude/impact the decision for surgery (e.g., increased risks of SSI with both diabetes and morbid obesity). Other major comorbidities included; acute myocardial infarction (MI) within the last 6 months (e.g. mortality up to 40%), contraindications to stopping antiplatelet therapy in patients with coated stents (e.g. within last 6 months–1 year), and heightened risks of phlebitis/pulmonary embolism, risks of stroke with mechanical heart valves, and hypercoagulation or hypocoagulation syndromes. Too often overlooked are the high risks for operative failure for those with major psychiatric disorders/chronic regional pain syndromes who often will not get better no matter how "good" the surgery.

## Avoid household pets (dogs/cats/other) prior to surgery: Carriers of MRSA

There is an increased risk of exposure to MRSA through contact with household pets; contact with them should, therefore, be avoided perioperatively. Cercenado and De Gopegui[5] evaluated community-acquired MRSA and observed, "…household pets and farm animals have also been implicated."

# CONCLUSIONS

There are many preoperative maneuvers that can mitigate the 0–10% risk of SSI following spine surgery. It is critical to limit the extent of the surgery and avoid fusion where feasible. It is important to appropriately use preoperative antibiotics (e.g. cefzolin and gentamicin), preoperative nasal cultures to diagnose/treat MRSA, and require bathing 2 weeks preoperatively (e.g. with CHG

4% – not just the night before/morning of surgery). Medical clearance should be performed up to 3 weeks preoperatively to assess; cardiac status (e.g. stress test), evaluate HBA1C to diagnose/treat diabetes, test for preoperative albumin/prealbumin levels (supplement if low), prescribe Tamsulosin for males over 60 (avoid POUR), and test for cessation of smoking. Further, timely cessation of anticoagulation, antiplatelet aggregants, NSAIDS, and vitamins/herbal supplements should decrease the risk of perioperative bleeding and seromas/hematomas that also may contribute to SSI.

## Financial support and sponsorship
Nil.

## Conflicts of interest
There are no conflicts of interest.

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