Prophylactic Postoperative Measures of Surgical Site Infection in Spine Surgery: Systematic Review and Recommendations

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ABSTRACT

Introduction

There are three phases in prophylaxis of surgical site infections (SSI): preoperative, intraoperative and postoperative. There is lack of consensus and paucity of evidence with SSI prophylaxis in the postoperative period. The authors systematically evaluate the literature, and provide evidence-based recommendations on postoperative measures for SSI prophylaxis in spine surgery.

Methods

A systematic review conforming to PRIMSA guidelines was performed utilizing PubMed (MEDLINE), EMBASE, and the Cochrane Database from inception to January 2019. The GRADE approach was used for quality appraisal and formulation of recommendation. Six postoperative care domains with associated key questions were identified. Included studies were extracted into evidence tables, data synthesized quantitatively and qualitatively, and evidence appraised per GRADE approach.

Results

Forty-one studies (9 RCT, 32 cohort studies) were included. In the setting of standard-of-care pre-incisional antimicrobial prophylaxis (AMP) administration, the use of postoperative AMP for SSI reduction is not necessary in decompression-only or lumbar spine fusion surgery. Prolonged administration of AMP for more than 48h postoperatively does not seem to reduce rate of SSI in decompression-only or lumbar spine fusion surgery. Utilization of wound drainage systems in lumbosacral spine and adolescent idiopathic scoliosis corrective surgery does not seem to alter the overall rate of SSI in spine surgery. Concomitant administration of AMP in the presence of a wound drain does not seem to reduce the overall rate of SSI, deep SSI, or superficial SSI in thoracolumbar fusion performed for degenerative and deformity spine pathologies, and in adolescent idiopathic scoliosis corrective surgery. Enhanced-recovery after surgery (ERAS) clinical pathways and infection-specific protocols does not seem to reduce rate of SSI in spine surgery. There is insufficient evidence to provide recommendations on all other types of spine surgeries with respect to their respective indications and postoperative SSI prophylactic measures. This also includes other non-AMP pharmacological measures, dressing type & duration, suture & staples management and postoperative nutrition for SSI prophylaxis in spine surgery.

Conclusion

Despite the postoperative period being key in SSI prophylaxis, the literature is sparse and without consensus on optimum postoperative care for SSI prevention in spine surgery. The current best

evidence is presented with its limitations. High quality studies addressing high risk cohorts such as the elderly population undergoing surgeries for trauma and oncology are urgently required.

Introduction

Surgical site infections (SSI) remain a feared complication of spine surgery, resulting in significant morbidity[1] and healthcare expenditure[2]. Perioperative measures are crucial in reducing SSI. Prophylaxis of SSI consists of three interconnected but distinct phases: preoperative, intraoperative and postoperative. As it is entrenched in surgical dogma that most SSI occur at the intraoperative phase with endogenous patient flora, much attention has been placed on the preoperative and intraoperative phases. Preoperative and intraoperative measures that have been used in spine surgery include antimicrobial prophylaxis (AMP), preoperative antiseptic bathes, intraoperative skin antiseptic preparation, intrawound vancomycin powder etc. The postoperative phase is comparably neglected and there is a paucity of evidence in terms of SSI prophylaxis[3].

In patients who are elderly (>65 years old), frail, or undergoing surgery for emergency, traumatic and oncologic indications, the rate of SSI and associated complications (e.g. death, wound dehiscence) is increased compared to the general population[4,5]. The importance of evidence-based measures to reduce SSI in this vulnerable subgroup attains added importance. However, there remains a dearth of literature for such patients, with the current evidence including patients predominantly with degenerative and deformity conditions.

As a result, the authors performed a systematic review of the literature pertaining to postoperative measures utilized in the prophylaxis of SSI in spine surgery. This review does not pertain to postoperative risk factors for SSI, it focuses on clinical measures for SSI prophylaxis in the postoperative period.

Methods

This systematic review is conducted in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines[6] (PROSPERO Registration: CRD42019131611). Recommendations based on quality and strength of available evidence is made using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) approach[7]. An initial rapid scoping review was conducted (T.T., M.H., H.L., results not published) to establish domains of postoperative care, refine study definitions, formulate key questions, and to determine breadth and level of evidence of the available literature. Conceptualization of the six postoperative care domains is shown in Figure 1.

Study Definitions & Formulation of Key Questions

This review included any postoperative measures utilized in the prophylaxis of SSI in spine surgery. Postoperative risk factors for SSI are not considered. On a methodological level, the distinction between "risk factor" and "prophylactic measure" is at times ambiguous, as alluded to by van Middendorp et. al.[8]

In this review, a "Postoperative measure" is defined as *any pharmacological or ward-based intervention that occurs after incisional wound closure used to prevent the occurrence of SSI*. For example, whilst postoperative blood transfusions (not a preventative measure) and tissue adhesives e.g. cyanoacrylates (used as part of wound closure and not *after* wound closure) are ineligible, wound staples/sutures (necessitating ward care and removal) and wound drains (necessitating ward care and removal) are eligible. We also included clinical care pathways that described at least one postoperative measure. As part of definition refinement in the initial rapid scoping review, two authors (T.T., M.H.) independently adjudged if a particular intervention met the definition of "postoperative measure". Any disagreement was resolved by discussion with the senior author (J.T.).

To guide the systematic review, key questions were formulated in accordance to the six identified postoperative care domains and refined throughout the rapid scoping review. A final version of the key questions was determined after consensus agreement between four authors (T.T., M.H., H.L., J.T.) as follows;

1) Domain: Pharmacological Measures
    - 1. Antimicrobial Prophylaxis (AMP)
        - Q1a. Does postoperative administration of AMP compared to standard pre-incision AMP decrease the risk of SSI in spine surgery?

        - Q1b. Does <48h of postoperative AMP compared to prolonged (>48h postoperative AMP decrease the risk of SSI in spine surgery?
    - Non-AMP Pharmacological Measures
        - Q1c. What (non-AMP) pharmacological measures can be used to reduce rate of SSI in spine surgery?
2) Domain: Wound & Dressing Care Management
    - Q2a. Is there an optimal type of postoperative dressing that reduces the rate of SSI in spine surgery? (including negative-pressure wound therapy)
    - Q2b. What is the minimum duration that dressings for uncomplicated wounds should be left intact to reduce the rate of SSI in spine surgery?
    - Q2c. How much time after surgery should elapse before patients are allowed to wet their wounds e.g. for showering/bathing
3) Domain: Suture and Staple Management
    - Q3a. ~~Is~~ there an optimal duration prior to removal of skin staples or (non-absorbable) sutures that minimizes the risk of development of SSI?
4) Domain: Drain Tube Management
    - Q4a. Does usage of a wound drain alter the risk of SSI in spine surgery?
    - Q4b. Does concomitant administration of AMP in the presence of a wound drain reduce the rate of SSI in spine surgery?
    - Q4c. Does early versus late removal of wound drains result in reduced rates of SSI in spine surgery?
5) Domain: Nutrition
    - Q5a. Does postoperative oral nutritional supplementation reduce the risk of SSI in spine surgery?
    - Q5b. Does early postoperative parenteral nutrition reduce the risk of SSI in spine surgery?
6) Domain: Clinical Care Pathways
    - Q6a. Does implementation of infection-specific care pathways reduce the rate of SSI in spine surgery?
    - Q6b. Do enhanced-recovery after surgery (ERAS) pathways reduce the rate of SSI in spine surgery?

Eligibility Criteria

All studies meeting the following criteria were included: 1) comparative study design, 2) meets definition of "postoperative measure", 3) patients undergoing spine surgery and 4) rate of SSI reported in intervention and control groups. There was no age restriction. We excluded case series and patients operated for infective spinal conditions (osteomyelitis, discitis, epidural abscess). Articles which reported generally on "wound complications", but not explicitly on SSI, were excluded.

Electronic Search Algorithm

A systematic search of the PubMed/Medline, EMBASE, Cochrane Review and Google Scholar from their date of inception till 23rd January, 2019 was performed. Individual searches were performed for each postoperative care domain. For example, the PubMed/Medline database was queried with Boolean combinations of the following general MeSH Headings (MH) and Key Topics (TS): "[MH] Surgical Wound Infection", "[TS] Surgical Site Infection", "[TS] Wound Infection", "[MH] Postoperative Complications", "[MH] Spine", "[MH] Spinal Fusion", "[MH] Lumbar Vertebrae", "[MH] Thoracic Vertebrae", "[MH] Cervical Vertebrae". These general search terms were then subjected to a targeted cross-search with specific postoperative measures e.g. "[MH] Antibiotic Prophylaxis" for each postoperative care domain. As an example, supplementary Table 1 provides the full search strategy for the PubMed database.

Only English language articles were included. Titles and/or abstracts were independently screened by two authors (T.T., H.L.). All articles that passed screening underwent full text review in duplicate (T.T., H.L.). Citations and bibliographies of all screened review articles and included studies were manually cross-referenced for any additional articles. Any disagreements regarding inclusion was adjudicated by a third author (J.T.).

Data Charting, Synthesis and Grading of Evidence

An electronic spreadsheet (Microsoft Excel, Redmonds, WA) with required data fields was created *a priori*. Data regarding authorship, publication year, title, postoperative care domain, objective, study design, postoperative prophylactic measure (intervention), population, sample size, and SSI outcome measure statistics were extracted. We paid attention to the underlying diagnosis/condition studied. The primary outcome measure is overall rate of SSI. Secondary outcome measures include superficial SSI and deep SSI (as defined by the Centers for Disease Control and Prevention [CDC]) . Evidence tables were constructed for each included study according to key question answered.

Meta-analysis was performed (OpenMetaAnalyst, Providence, Rhode Island) when the included evidence for a given key question was suitably homogenous in population, intervention, comparison,

and outcomes and when quantitative analysis enhances understanding of the key question. We calculated Risk Difference (RD) with 95% confidence intervals as our summary statistic using a random-effects (DerSimonian and Laird) model. We used RD due to possibility of zero events in groups and to draw a straightforward comparison benefit and harm for a given intervention. A p value of ≤0.05 was considered statistically significant. Where required and appropriate, non-parametric statistical analysis (e.g. Fisher's exact test) was performed using quantitative data from individual studies.

Risk of bias was systematically assessed for each individual study using scales developed by the ECRI Institute Penn Medicine Center for Evidence-Based Practice. When risk of bias is rated as "high" for >50% of studies making up the evidence-base for a given key question, the Study Quality was downgraded by one point in the GRADE tables.

The GRADE (Grading of Recommendations Assessment, Development and Evaluation) approach[7] was used to develop recommendations based on the derived evidence-base. From the evidence tables and risk of bias assessments, GRADE tables were produced to assess the overall quality of the evidence for each key question. Overall GRADE of the evidence at both individual-study and outcome level was graded as "High", "Moderate", "Low" to "Very Low" according to GRADE. A "Strong Recommendation" is made when a preponderance of evidence of at least moderate quality demonstrates a consistent effect (i.e. increase, decrease, no difference) on rate of SSI after spinal surgery. Similarly, a "Weak Recommendation" is made when a preponderance of evidence of low to very low quality demonstrates a consistent effect on rate of SSI. "No Recommendation" is made when there is insufficient evidence, or when there are inconsistent effects on rate of SSI. Where required, we paid attention to the type and diagnosis of surgery performed within the wording of the recommendation. The active voice is used for Strong recommendations to convey certainty ("does", "does not" etc.). The passive voice is used for Weak recommendations to convey reduced certainty ("should", "suggest", "consider" etc.).

Results

Search Results (Figure 2.)

The search algorithm returned a total of 2233 articles. 147 articles were selected for full text review after initial screening of titles and/or abstracts. 36 articles met the inclusion criteria after full text review. Manual searching of included articles' citations and bibliography, and of relevant systematic reviews generated a further 5 articles for inclusion. Thus, a total of 41[9-49] articles are included in this systematic review.

General Study Characteristics

Of the 41 included articles, 9 (22.0%) were randomized controlled trials (RCT) [10,11,18,19,28,32,39,42,45] and the remaining 32 (78.0%) were cohort studies. The manuscript by Kim et. al.[24], though stated as a RCT, is a cohort study by described methodology and thus assessed as such. Of the cohort studies, 26 (81.2%) were retrospective[9,13-15,17,20,22,23,25-27,29-31,33-38,40,41,44,46,47,49], 3 (9.4%) were prospective[16,21,24], and 3 (9.4%) was ambispective[12,43,48] in study design. The number of patients in included RCTs ranged from 30 to 326 (Median: 155), whilst that in cohort studies ranged from 42 to 10,225 (Median: 265.5). 17 of 30[12,15,18,21,22,24-26,31,32,35,40,42,43,45,47,48] studies contained information regarding deep or superficial location of SSI. Assessment of risk of bias for each individual study is shown in Supplementary Table 2.

Postoperative Care Domains

Six postoperative care domains were conceptualized: 1) Pharmacological measures, 2) Wound & Dressing Care management, 3) Suture and Staple management, 4) Drain tube management, 5) Nutrition and 6) Clinical care pathways (Figure 1).

1) Domain: Pharmacological measures

   Q1a. Does postoperative administration of AMP compared to standard pre-incisional AMP decrease the risk of SSI in spine surgery?

   Recommendation [Strong recommendation, Moderate quality evidence] In the setting of standard of care pre-incisional AMP administration, the use of postoperative AMP for SSI reduction is not necessary in decompression-only on lumbar spine fusion surgery.
   There is insufficient evidence to provide recommendations on postoperative AMP administration to reduce the rate of SSI in other types of spine surgery.

The available evidence examined the impact of postoperative administration of AMP compared to standard of care pre-incisional AMP on the rate of SSI. Patients receiving postoperative AMP also received pre-incisional AMP. The evidence for this comparison is derived from five studies, consisting of 1 RCT[18] and 4 OBS[14,21,25,34].

Moderate quality evidence at the outcome level show no benefit of postoperative AMP administration with respect to SSI rate reduction in a meta-analysis of five studies (N=3070) of patients undergoing predominantly decompression-only and spinal fusion surgery of the lumbosacral spine. Further subgroup meta-analysis was performed for patients undergoing decompression-only surgery[14,21,34] (three studies, N=1826), and for patients undergoing spinal fusion[18,34] (three studies, N=1244), similarly demonstrating no benefit of postoperative AMP administration.

Duration of administration of postoperative AMP was inconsistent between studies. Postoperative AMP was administered from one day to ten days postoperatively. There was differing types and regimens of postoperative AMP used across studies.

Evidence was available from three studies[18,21,25] with respect to rates of superficial and deep SSI. Low quality evidence suggests no difference in rates of superficial or deep SSI when postoperative AMP is given compared to standard pre-incisional AMP. This was based on a meta-analysis (N=863) of all three studies[18,21,25]. Regimens for postoperative AMP differed for all three included studies.

One retrospective cohort study[43] (N=468) of patients undergoing fusion and decompression-only surgery compared the rate of SSI when standard pre-incisional AMP was given compared to postoperative intravenous AMP for 5-7 days. Of note, this latter group did not receive pre-incisional AMP. The authors reported no difference in the overall rate of SSI.

The findings of the evidence review and GRADE for SSI reduction are shown in Evidence Table 1a and GRADE Table 1a.

Q1b. Does <48h of postoperative AMP compared to prolonged (>48h postoperative AMP) decrease the risk of SSI in spine surgery?

Recommendation [Weak recommendation, Low quality evidence] Prolonged administration of AMP for more than 48h postoperatively does not seem to reduce rate of SSI when compared to when less than 48h of postoperative AMP is administered in decompression-only or lumbar spine fusion surgery.

There is insufficient evidence to provide recommendations on prolonged administration of AMP to reduce the rate of SSI in other types of spine surgery.

The available evidence examined the impact of <48h of postoperative AMP compared to >48h of postoperative AMP on the rate of SSI. All included patients received standard of care pre-incisional AMP. The evidence for this comparison is derived from 4 OBS studies[24,27,31,42], all of low or moderate risk of bias.

Low quality evidence at the outcome level indicate no benefit of prolonged >48h administration of AMP to reduce SSI. This was based on a meta-analysis of three studies[24,27,31] (N=1513) demonstrating no significant reduction in rate of SSI. The I^2 statistic was 0%, suggesting homogeneity between studies. All studies investigated adult patients who predominantly underwent lumbosacral surgery with or without fusion. Whilst these studies did record known risk factors (e.g. age, co-morbidities, surgical duration, need for blood transfusion) for SSI, univariate analysis was undertaken in one of the studies only, and no multivariable analysis was performed.

Evidence was available from two studies[24,31] with respect to rates of deep SSI. Very low-quality evidence suggests no difference in rate of deep SSI when more than 48h of postoperative AMP is used. This was based on a meta-analysis (N=689) of two studies[24,31] with different AMP regimens in the >48h AMP groups.

Low quality evidence from 1 RCT[42] of 156 patients undergoing instrumented fusion demonstrated no significant difference in SSI rate when 24h of postoperative AMP was given as compared to 72h of postoperative AMP.

The findings of the evidence review and GRADE for SSI reduction are shown in Evidence Table 1b and GRADE Table 1b.

Q1c. What (non-AMP) pharmacological measures can be used to reduce rate of SSI in spine surgery?

Recommendation [No recommendation] There is insufficient evidence to either recommend or not recommend any non-AMP pharmacological to reduce the rate of SSI in any type of spine surgery.

Two studies were identified from the literature. One study investigated hyperbaric oxygen[20], and one study investigated postoperative administration of prostaglandin E1 (PGE1)[12]. The

study by Inanmaz et. al.[20] investigated the use of hyperbaric oxygen (2.4 atmospheres for 90 min per day for 30 sessions over 6 weeks) versus standard postoperative ward management and its impact on SSI. This is a retrospective cohort study looking at a very specific subset of spinal patients i.e. patients with neuromuscular scoliosis who underwent posterior instrumented fixation and fusion for deformity correction. The authors report a decrease in rate of SSI (5.5% versus 16.6%) in patients who received postoperative hyperbaric oxygen therapy. Using qualitative data from the article's full text, we performed Fisher's exact test which demonstrated the result to be statistically non-significant (p=0.37).

Demura et. al.[12] investigated the use of PGE1 (60µg twice a day for 7 days postoperative) versus standard postoperative ward management. This is an ambispective study with the patients receiving PGE1 enrolled prospectively. All patients in this study had spinal metastasis with preoperative irradiation and operation in the form of total enbloc spondylectomy or debulking/decompression surgery with stabilization. The authors report a significant decrease in rate of SSI (3.2% versus 31.8%, p=0.046) in patients who received postoperative PGE1. All diagnosed SSIs were in the deep location.

As these studies included a restricted subset of the spine surgery population (neuromuscular scoliosis, metastatic spinal tumors), the evidence was downgraded by one point due to indirectness and lack of generalizability as per GRADE. The resultant level of evidence is very low.

The findings of the evidence review and GRADE for SSI reduction are shown in Evidence Table 1c and GRADE Table 1c.

2) Domain: Wound and Dressing Care management

Q2a. Is there an optimal type of postoperative dressing that reduces the rate of SSI in spine surgery? (including negative-pressure wound therapy)

Recommendation [No recommendation] There is insufficient evidence to provide recommendations on any particular dressing type to reduce the rate of SSI in any type of spine surgery.

Two studies evaluated measures of wound care management and its effects on SSI[9,15]. Of these, one study investigated negative pressure wound therapy, and one study investigated

silver-impregnated dressings. The overall GRADE of the evidence at outcome level was very low. Both studies had low risk of bias.

In a retrospective cohort of 160 patients undergoing thoracolumbar fusion for deformity correction by Adogwa et. al.[9], 46 patients who received negative pressure wound therapy (-80mmHg) for 3 days postoperatively and was compared to standard multi-layered wound closure. The authors reported a significant decrease in SSI in patients who had negative pressure wound therapy (10.6% versus 14.9%, p=0.04). In 234 patients undergoing lumbar laminectomy with posterolateral instrumented fusion, Epstein et. al.[15] compared the use of silver-impregnated dressings applied at the conclusion of surgery and left intact for two weeks compared to the institution's standard dressing of an alcohol (or iodine) swab with a dry gauze. There were no cases of SSI in the silver-impregnated dressing group, compared to 11 infections (Deep: n=3 [2.34%], Superficial: n=8 [8.59%]) in the standard dressing group. Due to the small number of events with respect to secondary outcomes measures (deep/superficial SSI), location of SSI was not assessed in our GRADE analysis.

The findings of the evidence review and GRADE for SSI reduction are shown in Evidence Table 2a and GRADE Table 2a.

Q2b. What is the minimum duration that dressings for uncomplicated wounds should be left intact to reduce the rate of SSI in spine surgery?

Recommendation [No recommendation] There is insufficient evidence to provide recommendations on the duration for which wound dressings should remain intact to reduce rate of SSI in any type of spine surgery.

One large (N=8631) retrospective cohort study investigating duration of dressings was identified. Patients undergoing spinal fusion (all spinal levels) either had their dressings left intact for the first 5 postoperative days, or had their dressings changed within the first 5 postoperative days according to individual surgeon discretion. The authors reported a significant reduction in rate of SSI (from 3.9% to 0.93%, p=0.004).

The findings of the evidence review and GRADE for SSI reduction are shown in Evidence Table 2b and GRADE Table 2b.

Q2c. How much time after surgery should elapse before patients are allowed to wet their wounds e.g. for showering/bathing

Recommendation [No recommendation] There is insufficient evidence to provide recommendations on the ideal duration post-surgery to return to showering for the purposes of SSI reduction in any type of spine surgery.

One study was identified[48]. In an ambispective cohort study (N=192) of patients undergoing posterior thoracolumbar spinal surgery (including decompression-only and fusion surgery), there was no significant difference in the rate of SSI when patients were allowed to shower within 2-5 days postoperatively, versus when showering was allowed 10-16 days postoperatively. All patients had skin staples for dermal closure. In the early shower group, incisions were dried and covered with gauze dressings after showers
The findings of the evidence review and GRADE for SSI reduction are shown in Evidence Table 2c and GRADE Table 2c.

3) Domain: Suture and Staple management

Q3a. Is there an optimal duration prior to removal of skin staples or (non-absorbable) sutures that minimizes the risk of development of SSI?

Recommendation [No recommendation] No studies met the inclusion criteria for evaluation of this key question.

4) Domain: Drain tube management

Q4a. Does usage of a wound drain alter the risk of SSI in spine surgery?

Recommendation [Strong recommendation, High quality evidence] Utilization of wound drainage systems do not alter the overall rate of SSI in lumbosacral spine and adolescent idiopathic scoliosis corrective surgery.
There is insufficient evidence to provide recommendations on the utilization of wound drainage systems to reduce the rate of SSI in other types of spine surgery.

The available data examined the use of wound drainage versus no wound drainage and its impact on rate of SSI in spine surgery. Both supra-fascial and sub-fascial wound drainage were included without sub-group analysis according to location of drain. The evidence for this comparison is derived from 5 RCTs[10,11,28,39,45] and 8 OBS[13,23,29,30,33,40,44,49].
High quality evidence at the outcome level suggested no difference in rate of SSI when wound drainage systems were used. This was based on a meta-analysis (N=2443) of twelve studies[10,11,13,23,28-30,33,39,40,44,45] which found no significant difference in rate of SSI (RD=0.001, 95% CI -0.006 to 0.007, p-0.844). Further sub-group meta-analyses of adult patients undergoing decompression-only lumbosacral surgery (5 studies[11,28,29,44,50], N=950), and of adult patients undergoing lumbosacral fusion surgery (4 studies[11,33,40,45], N=643), and patients with adolescent idiopathic scoliosis (2 studies[10,13], N=530) similarly demonstrates no significant differences in the rate of SSI when wound drainage is used postoperatively.

The findings of the evidence review and GRADE for SSI reduction are shown in Evidence Table 4a and GRADE Table 4a.

Q4b. Does concomitant administration of AMP in the presence of a wound drain reduce the rate of SSI in spine surgery?

Recommendation [Weak recommendation, Low quality evidence] The concomitant administration of AMP in the presence of a wound drain does not reduce the overall rate of SSI, deep SSI, or superficial SSI in thoracolumbar fusion for degenerative and deformity (adult degenerative and adolescent idiopathic scoliosis) conditions.
There is insufficient evidence to provide recommendations on the concomitant administration of AMP in the presence of a wound drain to reduce the rate of SSI in other types of spine surgery.

The available data examined the concomitant administration of AMP for as long as a wound drain remains in situ postoperatively. The evidence base is derived from 1 RCT[32] and 1 OBS[22]. In the OBS by Kamath et.al.[22], the control group received two doses of AMP postoperatively whilst patients in Takemoto et.al.'s[32] RCT received 24h of postoperative AMP.
High quality evidence from one moderate-size RCT[32] with low risk of bias found no difference in rate of SSI in 314 patients who underwent multi-level thoracolumbar fusion

either for spinal degeneration of deformity. The total duration of wound drainage lasted an average of 3.0 to 3.2 days. Considering the total evidence base, the overall GRADE was downgraded by two points due to indirectness of the study population. Both studies included in the evidence base looked at a specific subset of spine surgery patients, namely adolescent idiopathic scoliosis and thoracolumbar fusion.

There were no statistically significant differences in the rates of superficial SSI and deep SSI when AMP is administered continuously when a wound drain is in situ versus when AMP is administered for up to 24h postoperatively. This is based on evidence from the same two studies as above[22,32].

The findings of the evidence review and GRADE for SSI reduction are shown in Evidence Table 4b and GRADE Table 4b.

Q4c. Does early versus late removal of wound drains result in reduced rates of SSI in spine surgery?

Recommendation [No recommendation] No studies met the inclusion criteria for evaluation of this key question.

5) Domain: Nutrition

Q5a. Does postoperative oral nutritional supplementation reduce the risk of SSI in spine surgery?

Recommendation [No recommendation] No studies met the inclusion criteria for evaluation of this key question.

Q5b. Does early postoperative parenteral nutrition reduce the risk of SSI in spine surgery?

Recommendation [No recommendation] There is insufficient evidence to provide recommendations on the use of postoperative parenteral nutritional to reduce the rate of SSI in any type of spine surgery.

One study investigated the use of total parenteral nutrition (TPN). Hu et. al.[19] conducted a RCT to study the effects of postoperative total parenteral nutrition in patients undergoing

staged anterior followed by posterior spine surgery spaced 7 days apart. All patients commenced oral intake after bowel sounds and flatus was present. In the intervention group, TPN was commenced immediately after the first stage and continued through the second stage until oral caloric intake was sufficient. The authors found no significant difference between the TPN and non-TPN group with respect to rate of SSI (18.8% versus 5.3%, p-value not reported). Using quantitative data from the full text, we calculated a p value of >0.05 (not statistically significant) for the reported rates of SSI (Fisher's exact test).

The findings of the evidence review and GRADE for SSI reduction are shown in Evidence Table 5b and GRADE Table 5b.

6) Domain: Clinical Care Pathway

Q6a. Does implementation of infection-specific care pathways reduce the rate of SSI in spine surgery?

Recommendation [Weak recommendation, Very Low-quality evidence] Implementation of infection-specific protocols has not been shown to reduce the overall rate of SSI in paediatric and adult degenerative spine surgery.

5 OBS studies[16,17,26,46,47] investigated the implementation of care pathways or protocols and its impact on SSI. At the outcome level, very low-quality evidence indicates no difference in overall SSI rate with implementation of infection-specific protocols. All five studied protocols included different elements from one another. These care pathways consist of clinical protocols with specific preoperative, intraoperative and postoperative measures. It was not possible to disambiguate or perform sub-analysis to quantify how much each component of the protocol contributed to rate of SSI reduction. As such, quality of evidence was downgraded due to indirectness of the intervention's effect upon the outcome measure as per GRADE guidelines. In a meta-analysis of two studies[16,26] (N=1686) of adults undergoing spine surgery, there was no significant difference in the rate of SSI with implementation of an infection-specific protocol (RD=-0.012, 95% CI -0.026 to 0.003, p=0.127). The study by Agarwal et.al.[46], investigating the impact of a infection-prevention pathway plus physician awareness campaign, found no difference in rate of overall SSI. This study was excluded from the above meta-analysis due to heterogeneity in sample population and unequal sample sizes across groups.

Two studies investigated infection-prevention protocols in the pediatric population[17,47]. Gould et. al.[17], applying a care protocol including postoperative wound education and dressing management at discharge, found a trend towards reduced SSI rate in pediatric patients undergoing spinal fusion. Glotzbecker et.al.,[47] in a retrospective cohort study of high-risk pediatric patients undergoing multi-level posterior spinal fusion, similarly found no difference in overall rate of SSI when a multidisciplinary infection-specific pathway was implemented.

Two studies [26,47] reported on the rates of deep SSI, with both reporting statistically significant decreases in rate of deep SSI with implementation of infection-specific protocols. One of the studies investigated adults[26], and the other investigated high-risk pediatric patients[47]. Due to the very low-quality overall GRADE of the evidence base, and the heterogeneity between the two studies, there is insufficient evidence to make recommendations on the impact of infection-specific protocols on rate of deep SSI.

The findings of the evidence review and GRADE for SSI reduction are shown in Evidence Table 6a and GRADE Table 6a.

Q6b. Do enhanced-recovery after surgery (ERAS) pathways reduce the rate of SSI in spine surgery?

Recommendation [Weak recommendation, Low quality evidence]
Current evidence suggests that ERAS clinical pathways does not seem to reduce rate of SSI in spine surgery.

The available data examined the instituion of enhanced-recovery after surgery clinical pathways on postoperative outcomes in spine surgery. The evidence base is derived from 4 recent OBS[35-38]. ERAS is a perioperative protocol standardizing elements of surgical care inculding preoperative education, opioid-sparing analgesia, minimally invasive surgery, early postoperative nutrition, early postoperative mobilisation etc. None of the studies had SSI as its primary outcome measure. Primary outcome measures in ERAS studies are usually length of stay, and lack of increase in overall adverse events. Whilst principles or ERAS is similar between studies, exact protocol items differ between institutions. Low quality evidence on an outcome level and meta-analysis of all four studies (N=5570) demonstrates no difference in rate of SSI when ERAS clinical pathways are instituted. Subgroup meta-analysis of two

studies[36,37] (N=5230) on adult patients and two studies[35,38] (N=340) on patients with adolescent idiopathic scoliosis similary demonstrate no difference in risk of SSI. The studies all had low (75%) or moderate (25%) levels of risk of bias. Rao et.al[35], in their description surgical complications, indicate the location (i.e. deep versus superficial) of the SSIs that occurred (see Evidence Table). Due to the small number of events, we did not include this (deep SSI, superficial SSI) in our GRADE analysis.

The findings of the evidence review and GRADE for SSI reduction are shown in Evidence Table 6b and GRADE Table 6b.

Discussion

Surgical site infections in surgery is generally preventable. Research has revolved around preoperative and intraoperative measures to reduce SSI, and there is a relative neglect of postoperative measures[3]. Further, whilst a multitude of studies have investigated preoperative (e.g. demographical) and intraoperative risk factors for SSI, postoperative risk factors are not as thoroughly studied. This lack of identification of postoperative risk factors further compounds our inability to initiate measures to mitigate postoperative risk factors.

Through a rapid scoping review to delineate and clarify the boundaries of the current systematic review, the authors identified six domains of care where postoperative measures can be applied: 1) Pharmacological measures,2) Wound & Dressing Care management, 3) Suture and staple management, 4) Drain tube management, 5) Nutrition, 6) Clinical care pathways.

In terms of pharmacological measures, AMP administration has been consistently found to significantly reduce SSI in spine surgery. It is undisputed that pre-incisional and periodical intraoperative dosing of intravenous AMP (e.g. every 3 hours during surgery) are critical in SSI prevention. Guideline recommendations[51] from the Centers of Disease Control and Prevention (CDC) have advocated against postoperative AMP given the lack of evidence that it reduces SSI. This is consistent with the findings from this review. The included studies investigated a large number of patients receiving a wide range of spine surgeries including simple decompression to multilevel instrumented fusion and fixation. It should be noted that most of these studies included patients only with degenerative conditions, and extension of the findings to other conditions should be tentative. For example, spine surgery in trauma and oncology are known to experience increased SSI rates. Nonetheless, current evidence consensus does not support the administration of postoperative AMP to reduce SSI.

Two separate studies[12,20] investigated the use of hyperbaric oxygen therapy and PGE1 for SSI reduction. PGE1 is a potent vasodilator that has been previously found to reduce SSI in laryngeal surgery post irradiation[52]. Demura et. al[12], in a retrospective study of post-irradiative patients with spinal metastases, demonstrated a significant reduction in rate of SSI of patients who had undergone debulking/excision and stabilization surgery. The evidence for both hyperbaric oxygen therapy, and PGE1 is of limited and very low quality and further studies will be required to ascertain its effectiveness in SSI reduction.

Wound care management is a major area of care in the postoperative period, but the evidence behind current clinical practice is dismal. There is insufficient evidence to provide recommendations

on any of the following: ideal dressing type, duration of dressings to be left intact postoperatively, nursing care of wounds in the event of minor wound complications and return to showering. Two comparative studies investigating type of dressings were identified studying the use of negative pressure wound therapy[9] and silver-impregnated dressings[15]. Negative pressure wound therapy has been often used in orthopedic surgery[53] and general surgery, where it has been found to reduce rates of SSI, wound dehiscence and postoperative seroma development[54]. The use of negative wound pressure therapy is unwarranted in spine surgery involving low levels of surgical invasiveness, e.g. microdiscectomy, single-level laminectomy, anterior cervical discectomy and fusion. However, more invasive procedures e.g. long segment decompression and fusions, deformity corrections, experience a higher rate of SSI, seroma, and wound exudate. The use of negative pressure wound therapy in this setting should be further investigated. Regarding the need for routine dressing changes, the results from a large retrospective study by Bain et.al. suggests the utility of leaving dressings intact (unless soiled) for five days postoperatively and refraining from regular dressing changes in the first five postoperative days. Unfortunately, no formal recommendations can be made given the lack of other corroborative studies. Current CDC SSI guidelines recommend, as a good clinical practice, to cover surgical incisions with an appropriate dressing for a period of 24h-48h[51]. The decision regarding return to showering remains an institution- or surgeon-specific domain rather than evidence-based. There was one study[48] demonstrating no significant differences in rate of SSI in patients undergoing decompression or fusion of the thoracolumbar spine when patients were allowed to shower from the 5th postoperative day. Studies of non-spinal, clean and clean-contaminated wounds[55] have similarly demonstrated the safety of early (after 48h postoperatively) showering, with concomitant increase in patient satisfaction rates.

There were no comparative studies found regarding postoperative dermal staple and suture management. In the clinical setting, there is a wide range of practices regarding the total duration that staples and non-absorbable sutures should remain in-situ in the postoperative management. These practices are borne from surgeon-preference, patient factors and surgical factors (e.g. redo surgery). Of course, the use of dissolvable sutures obviates the need for any suture removal. A systematic review of absorbable versus nonabsorbable sutures for dermal closure in all surgical incisions demonstrated no increase of SSI, wound dehiscence or cosmetic outcomes[56]. In a separate wide-ranging systematic review by Yilmaz et. al.[57], the authors concluded that use of surgical staples was associated with an increase in SSI rate in posterior spine surgery compared to use of suture closure. This statement should however be interpreted with much caution as it is derived from a single retrospective study by Ando et. al.[58] comparing staple dermal closure to 2-octyl cyanoacrylate tissue adhesive dermal closure.

Leaving a wound drain is a double-edged sword in spine surgery. On one hand, wound drains are foreign material that can act as a nidus of colonization for bacteria with resultant direct inoculation and infection. In a study on patients undergoing breast surgery[59], bacterial drain colonization was an independent risk factor for development of SSI. On the other hand, wound drainage reduces the amount of discharge and exudate through the wound, which can lead to improved wound healing during the acute postoperative period and resultant decreased SSI. Recent systematic reviews have on this topic have consistently found that when wound drains are placed, it does not increase the rate of SSI[60-62]. Further, whilst wound drains can prevent large-volume serous wound ooze, this does not translate into a lower SSI. The findings from the current study is consistent with previous studies and recapitulates the notion that presence of a drain tube, does not directly impact upon the rate of SSI. Moreover, the occurrence of SSI in the presence of a drain tube is independent of whether AMP were administered whilst the drain tube is in-situ. The current evidence base does not allow for a recommendation to be made regarding optimal timing for drain removal for the purposes of preventing SSI as no studies have actively investigated early versus late wound drain removal. In large retrospective series[63,64], duration of drainage has been found to be a significant predictor of subsequent development of SSI after spine surgery.

Malnutrition is a recognized risk factor for SSI in surgery[65], including in spine surgery[66]. In the 2016 WHO recommendations[67,68], a conditional recommendation for enteral or oral nutritional supplementation for the purposes of SSI reduction was made. Nutritional supplementation in this instance is administered perioperatively (starting preoperatively), and usually extends to the postoperative period. Whilst conceptually simple, the identification of malnourished patients who will benefit most from nutritional supplementation, and the costs involved in providing this supplementation has prevented rigorous implementation and study in this area. There are currently no comparative studies that have investigated the effects of parenteral or oral nutritional supplementation on SSI in spine surgery (either in the preoperative or postoperative period). In the only comparative study relevant to spine surgery, Hu et. al.[19] found no difference in SSI when TPN was administered to patients undergoing two stage (anterior followed by posterior surgery). Clearly, there is a need for further study into the effects of perioperative nutritional supplementation and spine surgery.

In this review, we have included postoperative care pathways as a specific domain. We included both infection-specific care pathways and enhanced-recovery after surgery pathways. These are clinical protocols and pathways that are instituted as “best clinical practice” to be adhered to during the three phases of surgical care. Each individual component of a pathway differentially contributes

to the pathway's overall efficacy, and probably acts synergistically. As such, it is not possible to disambiguate the effects of the individual components. The five included studies with infection-specific pathways[16,17,26,46,47], whilst including postoperative measures in their pathway, focuses primarily on the preoperative and intraoperative phase. ERAS pathways were initially created in colorectal surgery[69] and has since spread throughout all of surgery. ERAS is a multidisciplinary perioperative approach to improve recovery after surgery, resulting in decreased length of stay without increased adverse events. The low-quality evidence available suggests that ERAS pathways do not result in reduction of SSI. However, amalgamating 1) ERAS principles, 2) current standard of care perioperative SSI preventative measures and 3) an infection-specific pathway incorporating all 6 postoperative care domains may represent the ultimate SSI reduction measure in spine surgery. The paucity of evidence surrounding the postoperative period makes this prospect difficult at present.

It is evident from this review that there is a scarcity of evidence pertaining to patients undergoing emergent, traumatic, and oncologic surgery. The increased rates of SSI and resultant morbidity in these cohorts are potentially more devastating in an already compromised patient group. Further, the global ageing population will increase the number of elderly and frail patients[70] undergoing spine surgery. There is good evidence that frailty (as measured by indices such as the modified frailty index) is associated with increased postoperative mortality and morbidity in emergent general surgery[71], orthopaedic trauma[72] and elective spine surgery[73]. Whilst a certain degree of generalizability of results to these at-risk populations is reasonable, there remains a strong need for targeted research into measures to prevent SSI in the elderly, frail, trauma and oncologic population.

Limitations

This review has several limitations. On an intra-study level, most of the included studies did not differentiate between a superficial and deep SSI. As such, we were only able to synthesize and present information on superficial and deep SSI on a piecemeal basis when available. The implications of a deep SSI are more severe, often dictating operative wound debridement and washout and increased economic costs. Further, most of the included studies do not include multivariate analysis of the variable of interest against the outcome of SSI. This methodological flaw increases the risk of bias of the study and mitigates the strength of recommendations made based on the study. On an inter-study level, the included studies are highly heterogeneous from one another, with differing study designs, patient demographics, indications for surgery and surgical invasiveness/type of surgery. Whilst this was a purposeful result of the broad inclusion criteria in the current review, it results in substantial heterogeneity, especially in terms of the included population. On the review level, this study is limited by the small number of studies included in general for each

of the identified postoperative care domains. For example, no studies were found for staple and suture management. This points towards the knowledge and research gap that currently exists for postoperative measures for SSI prophylaxis in spine surgery.

Conclusion

Despite the postoperative period being key in SSI prophylaxis, the literature is sparse and without consensus on optimum postoperative care for SSI prevention in spine surgery. The current best evidence is presented with its limitations. High quality studies addressing high risk cohorts such as the elderly population undergoing surgeries for trauma and oncology are urgently required.

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Supplmentary Table 1. PubMed/Medline Search Strategy

Set	MEDLINE Search History - " Postop SSI Antis"
#18	#17 AND #13 *DocType=All document types; Language=All languages;*
#17	#16 OR #15 OR #14 *DocType=All document types; Language=All languages;*
#16	TS=antibiotics *DocType=All document types; Language=All languages;*
#15	TS=(Perioperative antibiotics) *DocType=All document types; Language=All languages;*
#14	MH:exp=(Antibiotic Prophylaxis) *DocType=All document types; Language=All languages;*
#13	#12 AND #11 *DocType=All document types; Language=All languages;*
#12	#10 OR #9 OR #8 OR #7 OR #6 *DocType=All document types; Language=All languages;*
#11	#3 OR #2 OR #1 *DocType=All document types; Language=All languages;*
#10	MH:exp=(Thoracic Vertebrae) *DocType=All document types; Language=All languages;*
#9	MH:exp=(Cervical Vertebrae) *DocType=All document types; Language=All languages;*
#8	MH:exp=(Lumbar Vertebrae) *DocType=All document types; Language=All languages;*
#7	MH:exp=(Spinal Fusion) *DocType=All document types; Language=All languages;*
#6	MH:exp=Spine *DocType=All document types; Language=All languages;*
#5	MH:exp=(Postoperative Complications) Refined by: MeSH QUALIFIERS: (PREVENTION CONTROL) *DocType=All document types; Language=All languages;*
#4	MH:exp=(Postoperative Complications) *DocType=All document types; Language=All languages;*

#3	TS=(Wound infection) *DocType=All document types; Language=All languages;*
#2	TS=(Surgical Site Infection) *DocType=All document types; Language=All languages;*
#1	MH:exp=(Surgical Wound Infection) *DocType=All document types; Language=All languages;*

Set	MEDLINE Search History - " Postop SSI Drains"
#23	#22 AND #13 *DocType=All document types; Language=All languages;*
#22	#21 OR #20 OR #19 OR #18 OR #17 OR #16 OR #15 OR #14 *DocType=All document types; Language=All languages;*
#21	TS=(post-operative drain) *DocType=All document types; Language=All languages;*
#20	TS=(postoperative drain) *DocType=All document types; Language=All languages;*
#19	TS=(closed-suction drain) *DocType=All document types; Language=All languages;*
#18	TS=closed suction drain *DocType=All document types; Language=All languages;*
#17	TS=wound drain *DocType=All document types; Language=All languages;*
#16	TS=(Surgical site drain) *DocType=All document types; Language=All languages;*
#15	TS=Drain *DocType=All document types; Language=All languages;*
#14	MH:exp=Drainage *DocType=All document types; Language=All languages;*
#13	#12 AND #11 *DocType=All document types; Language=All languages;*
#12	#10 OR #9 OR #8 OR #7 OR #6 *DocType=All document types; Language=All languages;*
#11	#3 OR #2 OR #1 *DocType=All document types; Language=All languages;*
#10	MH:exp=(Thoracic Vertebrae) *DocType=All document types; Language=All languages;*
#9	MH:exp=(Cervical Vertebrae) *DocType=All document types; Language=All languages;*
#8	MH:exp=(Lumbar Vertebrae) *DocType=All document types; Language=All languages;*
#7	MH:exp=(Spinal Fusion) *DocType=All document types; Language=All languages;*

#6	MH:exp=Spine *DocType=All document types; Language=All languages;*
#5	MH:exp=(Postoperative Complications) Refined by: MeSH QUALIFIERS: (PREVENTION CONTROL) *DocType=All document types; Language=All languages;*
#4	MH:exp=(Postoperative Complications) *DocType=All document types; Language=All languages;*
#3	TS=(Wound infection) *DocType=All document types; Language=All languages;*
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Set	MEDLINE Search History - " Postop SSI Dressings"
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#17	TS=(postoperative nutrition) *DocType=All document types; Language=All languages;*
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#15	MH:exp=(Parenteral Nutrition, Total) *DocType=All document types; Language=All languages;*
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#3	TS=(Wound infection) *DocType=All document types; Language=All languages;*
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Set	MEDLINE Search History - " Postop SSI Protocols"

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#17	TS=(postoperative nutrition) *DocType=All document types; Language=All languages;*
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Set	MEDLINE Search History - " Postop SSI Shower"
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#7	MH:exp=(Spinal Fusion) *DocType=All document types; Language=All languages;*
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Set	MEDLINE Search History - " Postop SSI Sut/Stapl"
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#6	MH:exp=Spine *DocType=All document types; Language=All languages;*
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Set	MEDLINE Search History - " Postop SSI WoundCare"
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#17	TS=postoperative *DocType=All document types; Language=All languages;*
#16	TS=postoperative care *DocType=All document types; Language=All languages;*
#15	TS=wound care *DocType=All document types; Language=All languages;*
#14	TS=nursing care *DocType=All document types; Language=All languages;*
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#7	MH:exp=(Spinal Fusion) *DocType=All document types; Language=All languages;*
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Supplemental Table 2a. Risk of bias quality assessment for randomized controlled trials

Author Year	Domain	1) Described as randomized	2) Randomization appropriately performed (e.g. random number table, computerized scheme)	3) Described as double-blind	4) Outcome assessor blinded	5) Study participant blinded (e.g. interventions identical in appearance)	6) Investigator blinded (e.g. opaque sealed envelopes)	7) Attrition described	8) Attrition smaller than 10-15% of assigned patients	9) Attrition appropriately analyzed (e.g. intention to treat analysis)	10) Funding source(s) disclosed and no obvious conflict of interest	Points	Risk of Bias
Blank 2003	Drains	1	0	0	0	0	0	0	0	0	0	1	High
Brown 2004	Drains	1	1	0	0	0	1	1	1	1	1	7	Low
Hellbusch 2008	Antibiotics	1	0	0	0	0	0	1	1	1	0	4	Moderate
Hu 1998	Nutrition	1	1	0	0	0	1	1	1	0	0	5	Moderate
Payne 1996	Drains	1	1	0	0	0	1	1	1	1	0	6	Low
Takemoto 2015	Drains	1	1	0	0	0	1	1	1	1	1	7	Low
Gubin 2018	Drains	1	1	0	0	0	0	0	0	1	1	4	Moderate
Marimuthu 2016	Antibiotics	1	0	0	0	0	0	1	1	0	1	4	Moderate
Hung 2017	Drains	1	1	0	0	0	0	0	0	0	1	3	Moderate

Supplemental Table 2b. Risk of bias quality assessment for observation studies

Author Year	Domain	1) All study groups derived from similar source/reference populations	2) Attrition not significantly different across study groups	3) The measure of exposure is valid	4) The measure of outcome is valid	5) Investigators blinded to endpoint assessment	6) Potential confounders identified	7) Statistical adjustment for potential confounders done	8) Funding source(s) disclosed and no obvious conflict of interest	Points	Risk of Bias
Adogwa 2014	Dressings	1	1	1	1	0	1	1	1	7	Low
Demura 2009	Non-AMP Pharmaco	1	0	1	0	0	1	1	0	4	Moderate
Diab 2012	Drains	1	0	1	0	0	0	0	1	3	Moderate
Dobzyniak 2003	Antibiotics	1	1	1	1	0	1	0	1	6	Low
Epstein 2007	Dressings	1	1	1	1	0	1	0	0	5	Low
Featherall 2016	Protocol	1	0	1	1	0	1	1	1	6	Low
Gould 2016	Protocol	1	0	1	0	0	0	0	1	3	Moderate
Inanmaz 2014	Non-AMP Pharmaco	1	1	1	1	0	1	1	1	7	Low
Kakimaru 2010	Antibiotics	1	1	1	1	0	1	0	1	6	Low
Kamath 2016	Drains	1	1	1	1	0	1	0	1	6	Low
Kanayama 2007	Antibiotics	1	1	1	1	0	0	0	0	4	Moderate
Lewis 2018	Antibiotics	1	1	1	1	0	1	0	1	6	Low
Meyer 2010	Protocol	1	0	1	0	0	0	0	1	3	Moderate
Ohtori 2008	Antibiotics	1	1	1	0	0	0	0	1	4	Moderate

Sen 2005	Drains	1	1	1	0	0	1	0	0	4	Moderate
Sohn 2013	Drains	1	1	1	1	0	1	0	1	6	Low
Takahashi 2009	Antibiotics	1	1	1	1	0	1	1	1	7	Low
Walid 2012	Drains	1	1	1	0	0	1	0	1	5	Low
Debono 2019	Protocol	1	1	1	0	0	1	0	1	5	Low
Sivaganesan 2018	Protocol	1	1	1	0	0	1	0	1	5	Low
Rao 2017	Protocol	1	1	1	0	0	1	0	1	5	Low
Fletcher 2017	Protocol	1	1	1	0	0	0	0	1	4	Moderate
Kim 2010	Antibiotics	1	1	1	1	0	1	0	0	5	Low
Kanayama 2010	Drains	1	1	1	0	0	0	0	1	4	Moderate
Adogwa 2018	Drains	1	1	1	**1**	0	1	0	1	6	Low
Bains 2017	Dressings	1	1	1	1	0	0	0	1	5	Low
Numasawa 2015	Antibiotics	1	0	1	1	0	1	0	0	4	Moderate
Choi 2016	Drains	1	1	1	0	0	0	0	1	4	Moderate
Agarwal 2017	Protocol	1	0	1	1	1	0	0	1	5	Moderate
Glotzbecker 2018	Protocol	1	0	1	1	0	1	0	1	5	Moderate
Carragee 1996	Wound	1	1	1	0	1	1	0	0	5	Moderate
Poorman 2014	Drains	1	0	1	0	0	1	0	1	4	Moderate

Q1. Parenteral Antibiotic Microbial Prophylaxis

GRADE Table 1a. Does postoperative administration of AMP compared to standard pre-incision antibiotics decrease the risk of SSI in spine surgery?

GRADE Table 1b. Does 48h of postoperative AMP compared to prolonged (>48h postoperative AMP decrease the risk of SSI in spine surgery?

GRADE Table 1c. What (non-AMP) pharmacological measures can be used to reduce rate of SSI in spine surgery?

Q2. Wound and Dressing Management

GRADE Table 2a. Is there an optimal type of postoperative dressing that reduces the rate of SSI in spine surgery? (including negative-pressure wound therapy)

GRADE Table 2b. What is the minimum duration that dressings for uncomplicated wounds should be left intact to reduce the rate of SSI in spine surgery?

GRADE Table 2c. How much time after surgery should elapse before patients are allowed to wet their wounds e.g. for showering/bathing

Q4. Drain Tube Management

GRADE Table 4a. Does usage of a wound drain alter the risk of SSI in spine surgery?

GRADE Table 4b. Does concomitant administration of AMP in the presence of a wound drain reduce the rate of SSI in spine surgery?

GRADE Table 4c. Does early versus late removal of wound drains result in reduced rates of SSI in spine surgery?

Q5. Nutrition

GRADE Table 5a. Does postoperative oral nutritional supplementation reduce the risk of SSI in spine surgery?

GRADE Table 5b. Does early postoperative parenteral nutrition reduce the risk of SSI in spine surgery?

Q6. Clinical Care Pathways

GRADE Table 6a. Does implementation of infection-specific care pathways reduce the rate of SSI in spine surgery?

GRADE Table 6b. Do enhanced-recovery after surgery (ERAS) pathways reduce the rate of SSI in spine surgery?

Domain: 1. Pharmacologic Measures

Q1a. Does postoperative administration of AMP compared to standard pre-incision antibiotics decrease the risk of SSI in spine surgery?

Q1b. Does 48h of postoperative AMP compared to prolonged (>48h postoperative AMP decrease the risk of SSI in spine surgery?

GRADE Table 1a, 1b

					Decrease GRADE							Increase GRADE				
Comparison	**Outcome**	**Quantity and Type of Evidence**	**Findings**	**Starting GRADE**	**Study Quality**	**Consistency**	**Directness**	**Precision**	**Publication Bias**	**Large Magnitude**	**Dose-Response**	**Confounders**	**GRADE of evidence for outcome**	**Overall GRADE of evidence base**	**Comments if Up/Downgrade**
Q1a. Does postoperative administration of AMP compared to standard pre-incisional antibiotics decrease the risk of SSI in spine surgery?															
Postoperative antibiotics versus No postoperative antibiotics (In setting of pre-incisional antibiotics being given for both groups)	SSI	1 RCT (Hellbusch) 4 OBS (Dobzyniak, Kakimaru, Kanayama, Lewis)	- In a meta-analysis of all 5 studies (N=3070) in spine surgery, there was no difference in rate of SSI in patients receiving postoperative antibiotics (in addition to standard pre-incisional antibiotics) compared to patients who only received standard pre-incisional antibiotics: RD= 0.003 (-0.003 to 0.010), p=0.318, I^2=0 - In a subgroup meta-analysis of 3 studies (Dobzyniak, Kakimaru, Kanayama [subgroup]) (N=1826) investigating patients who underwent decompression-only spine surgery for degenerative spinal pathologies, there was no difference in rate of SSI in patients receiving postoperative antibiotics (in addition to standard pre-incisional antibiotics) compared to patients who only received pre-incisonal antibiotics: RD= 0.000 (-0.008 to 0.007), p=0.965, I^2=0% - In a subgroup meta-analysis of 3 studies (Hellbusch, Lewis, Kanayama [subgroup]) (N=1244) of patients undergoing spinal fusion, there was no difference in patients receiving postoperative antibiotics (in addition to standard pre-incisional antibiotics) compared to patients who only received pre-incisonal antibiotics: RD=0.007 (-0.008 to 0.022), p=0.378, I^2=23.06% - In the 5 included studies, postoperative antibiotic dose regimens ranged from 3 doses to 7 days postoperatively	High	0	-1	0	0	0	0	0	0	Moderate	Moderate	Evidence base downgraded by 1 for inconsistency in terms of different regimens of postoperative antibiotics administered, from 3 doses to 7 days postoperatively

	Superficial SSI	1 RCT (Hellbusch) 2 OBS (Kakimaru, Lewis)	- In a meta-analysis of 3 studies (N=863) in spine surgery, there was no difference in rate of superficial SSI when postoperative antibiotics were given compared to patients who only received pre-incisional antibiotics: RD= -0.003 (-0.016 to 0.011), p=0.706, I^2=0%	High	0	-1	0	-1	0	0	0	0	Low		Evidence base downgraded by one for inconsistency in individual study results, different AMP regimens and by one for large standard deviations in results
	Deep SSI	1 RCT (Hellbusch) 2 OBS (Kakimaru, Lewis)	- In a meta-analysis of 3 studies (N=863) in spine surgery, there was no difference in rate of deep SSI when postoperative antibiotics were given compared to patients who only received pre-incisional antibiotics: RD= 0.005 (-0.006 to 0.016), p=0.400, I^2=0%	High	0	-1	0	-1	0	0	0	0	Low		
Postoperative antibiotics (without pre-incisional antibiotics) versus Standard pre-incisional antibiotcs only	SSI	1 OBS (Numasawa)	- In a ambispective cohort studying of 468 patients undergoing both instrumented and non-instrumented spine surgery for both degenerative and non-degenerative conditions, there was no difference in the rate of SSI when postoperative IV AMP for 5-7 days were given (no pre-incisional or intraoperative AMP given) versus when only standard pre-incisional AMP was given	Low	0	0	0	0	0	0	0	0	Low		
Q1b. Does <48h of postoperative AMP compared to prolonged (>48h postoperative AMP) decrease the risk of SSI in spine surgery?															
48h postoperative antibiotics versus >48h postoperative antibiotics (In setting of pre-incisional antibiotics being given for both groups)	SSI	3 OBS (Kim, Ohtori, Takahashi)	- In a meta-analysis of all 3 studies (N=1513), there was no difference in rate of SSI in patients receiving postoperative antibiotics for >48h, compared to patients who received postoperative antibiotics for 48h: RD= -0.004 (-0.015 to 0.007), p=0.505, I^2=0% - In these 3 OBS, prolonged (>48h) of postoperative antibiotics was administered for a duration from 72h to 9 days postoperative. All patients in the above meta-analysis received standard pre-incisional antibiotics	Low	0	0	0	0	0	0	0	0	Low	Low	
	Deep SSI	2 OBS (Kim, Takahashi)	- In a meta-analysis of 2 studies (N=689) in spine surgery, there was no difference in rate of deep SSI when postoperative AMP were given for more than 48h compared to patients who only received 48h of postoperative AMP antibiotics: RD= -0.001 (-0.011 to 0.008), p=0.812, I^2=0%	Low	0	-1	0	0	0	0	0	0	Very Low		Evidence downgraded by one due to inconsistency in postoperative antibiotic regimens

24h postoperative antibiotics versus >48h postoperative antibiotics (In setting of pre-incisional antibiotics being given for both groups)	SSI	1 RCT (Marimuthu)	- In a moderate quality RCT of 156 patients undergoing instrumented spinal fusion, there was no significant difference in rate of SSI between patients given 24h versus 72h of postoperative AMP (1.18% vs. 2.56% respectively, p=0.43	High	0	0	-1	-1	0	0	0	0	Low		Evidence downgraded by one due to inconsistency in intervention: postoperative AMP regimen given in this study is uncommon. Evidence further downgraded by one for lack of precision and lack of power calculation for sample size in this RCT

Q1c. What (non-AMP) pharmacological measures can be used to reduce rate of SSI in spine surgery?

GRADE Table 1c.

					Decrease GRADE					Increase GRADE					
Comparison	**Outcome**	**Quantity and Type of Evidence**	**Findings**	**Starting GRADE**	**Study Quality**	**Consistency**	**Directness**	**Precision**	**Publication Bias**	**Large Magnitude**	**Dose-Response**	**Confounders**	**GRADE of evidence for outcome**	**Overall GRADE of evidence base**	**Comments if Up/Downgrade**
Q1c. What (non-AMP) pharmacological measures can be used to reduce rate of SSI in spine surgery?															
Hyperbaric oxygen therapy vs. Standard postoperative ward care	SSI	1 OBS (Inanmaz)	In a retrospective cohort study (N=42) study of neuromuscular scoliosis patients undergoing posterior deformity correction, the rate of SSI in the hyperbaric oxygen group was lower than that of the control group (5.5% vs. 16.6% respectively, no statistical analysis). Using numbers provided in Inanmaz et.al's manuscript, we applied Fisher's exact test, with the resultant p value of 0.37. Thus, the reduction in SSI seen with hyperbaric oxygen is not statistically significant.	Low	0	0	-1	0	0	0	0	0	Very Low	Very Low	Downgraded for indirectness due to study looking at neuromuscular scoliosis patients only
Prostaglandin E1 (PGE1) versus no Prostaglandin E1	SSI*	1 OBS (Demura)	In an ambispective, two-period, before and after study (Retrospective: non-PGE1 patients, Prospective: PGE1 patients) of patients (N=204) undergoing preoperative irradiation followed by debulking or en bloc spondylectomy and reconstructive fusion surgery for spinal metastases, the rate of SSI in the group receiving PGE1 was significantly lower than that of the control group (3.19% vs 31.8%, p=0.046) *: All diagnosed SSIs were deep SSIs	Low	0	0	-1	0	0	0	0	0	Very Low		Downgraded for indirectness due to study looking at spinal metastases patients receiving preoperative irradiation only

Domain: 2. Wound and Dressing Management

Q2a. Is there an optimal type of postoperative dressing that reduces the rate of SSI in spine surgery? (including negative-pressure wound therapy)

Q2b. What is the minimum duration that dressings for uncomplicated wounds should be left intact to reduce the rate of SSI in spine surgery?

Q2c. How much time after surgery should elapse before patients are allowed to wet their wounds e.g. for showering/bathing

GRADE Tables 2a, 2b, 2c

					Decrease GRADE					Increase GRADE						
Comparison	**Outcome**	**Quantity and Type of Evidence**	**Findings**	**Starting GRADE**	**Study Quality**	**Consistency**	**Directness**	**Precision**	**Publication Bias**	**Large Magnitude**	**Dose-Response**	**Confounders**	**GRADE of evidence for outcome**	**Overall GRADE of evidence base**	**Comments if Up/Downgrade**
Q2a. Is there an optimal type of postoperative dressing that reduces the rate of SSI in spine surgery? (include negative-pressure wound therapy)															
Silver-impregnated dressings versus gauze dressing	SSI	1 OBS (Epstein)	In a retrospective cohort study (N=234) of patients undergoing lumbar laminectomy with instrumented fusion, the rate of SSI in patients receiving silver-impregnated dressings postoperatively was lower compared to that of patients receiving standard gauze dressings (0% vs. 8.59% respectively, no statistical analysis)	Low	0	0	0	0	0	0	0	0	Low	Very Low	
Negative-pressure wound therapy versus standard dressing of xeroform, gauze, and medopore tape	SSI	1 OBS (Adogwa)	In a retrospective, two-period, before and after cohort study (N=160) of patients undergoing long-segment thoracolumbar fusion for deformity correction, patients receiving negative pressure wound therapy (for three days postoperatively) had a significantly lower rate of SSI compared to xeform with gauze dressings (10.6% vs. 14.9% respectively, p=0.04)	Low	0	0	0	-1	0	0	0	0	Very Low		Study downgraded due to significantly unequal number of patients between test and control groups (test: n=46, control: n=114)
Q2b. What is the minimum duration that dressings for uncomplicated wounds should be left intact to reduce the rate of SSI in spine surgery?															

No dressing changes for (at least) 5 days postoperatively vs. Dressing changes within ithe first 5 postoperative days	SSI	1 OBS (Bains)	In a retrospective cohort study (N=8631) of patients undergoing spinal fusion at all spinal levels, the rate of SSI was compared between patients who had wound dressings left intact for (at least) the first 5 postoperative days versus patients who had dressing changes within the first 5 postoperative days. The overall rate of SSI was lower in the group whose dressings were left intact for 5 days postoperatively (0.93% to 3.9%, p=0.0041)	Low	0	0	0	0	0	0	0	0	Low	Low	
Q2c. How much time after surgery should elapse before patients are allowed to wet their wounds e.g. for showering/bathing															
Allowed to shower between 2-5 days postoperatively vs. Allowed to shower after 10-16 days postoperatively	SSI	1 OBS (Carragee)	In an ambispective cohort study (N=192) of patients undergoing posterior thoracolumbar spinal surgery (including decompression-only and fusion surgery), there was no difference in the rate of SSI when patients were allowed to shower within 2-5 days postoperatively, versus when showering was allowed 10-16 days postoperatively. In this study the skin was closed with staples. In the early shower group, incisions were dried and covered with gauze dressings after showers	Low	0	-1	-1	0	0	o	o	o	Very Low	Very Low	Study downgraded by one due to inconsistency of the interventions in terms of have differring number of days where patients are allowed to shower within groups. Study also downgraded due to indirectness of population given only patients undergoing posterior thoracolumbar surgery was included

Domain: 4. Drain Tube Management

Q4a. Does usage of a wound drain alter the risk of SSI in spine surgery?

Q4b. Does concomitant administration of AMP in the presence of a wound drain reduce the rate of SSI in spine surgery?

Q4c. Does early versus late removal of wound drains result in reduced rates of SSI in spine surgery?

GRADE Tables 4a, 4b, 4c

				Decrease GRADE					Increase GRADE						
Comparison	**Outcome**	**Quantity and Type of Evidence**	**Findings**	**Starting GRADE**	**Study Quality**	**Consistency**	**Directness**	**Precision**	**Publication Bias**	**Large Magnitude**	**Dose-Response**	**Confounders**	**GRADE of evidence for outcome**	**Overall GRADE of evidence base**	**Comments if UP/DOWNGRADE**
Q4a. Does usage of a wound drain alter the risk of SSI in spine surgery?															
Wound drain vs. No wound drain	SSI	5 RCT (Blank, Brown, Payne, Gubin, Hung) 8 OBS (Diab, Sen, Sohn, Walid, Kanayama, Adogwa, Choi, Poorman)	- Meta-analysis of 12 studies (N=2443) of patients undergoing posterior spinal surgery demonstrates no significant difference in risk of SSI between patients with drains vs. without drains: RD= 0.001 (-0.006 to 0.007); p=0.844, I^2=0 - Meta-analysis of 1 RCT and 1 OBS (N=530) of adolescent patients (<18 years) with adolescent idiopathic scoliosis shows no difference in risk of SSI with the use of wound drain post corrective scoliosis surgery: RD=-0.088 (-0.315 to 0.139); p=0.445, I^2=71.45% - Meta-analysis of 2 RCT and 3 OBS (N=950) of adult patients undergoing decompression-only lumbosacral surgery demonstrates no difference in risk of SSI with use of wound drains: RD=0.000 (-0.007 to 0.007); p=0.966, I^2=0% - Meta-analysis of 2 RCT and 2 OBS (N=643) of adult patients undergoing lumbosacral decompression and fusion surgery demonstrates no difference in risk of SSI with use of wound drains: RD=0.010 (-0.018 to 0.038); p=0.491, I^2=0% - 1 retrospective cohort study (Sohn) of 169 patients undergoing primary intradural	High	0	0	0	0	0	0	0	0	High	High	

			spinal tumour surgery, there was no difference in rate of SSI with the use of closed suction wound drains (Drain SSI: 2.67% vs No Drain SSI: 0%, p=0.20) - 1 retrospective cohort study (N=81) of adult patients undergoing anterior cervical discectomy and fusion demonstrates no difference in rate of SSI when drains were used vs. when no drains were used (0% vs. 2.4% respectively, p=0.33)												
Q4b. Does concomitant administration of AMP in the presence of a wound drain reduce the rate of SSI in spine surgery?															
AMP administration whilst wound drain in-situ vs. No AMP coverage whilst wound drain in-situ	SSI	1 RCT (Takemoto) 1 OBS (Kamath)	- In 1 RCT (Takemoto) of 170 adult (>18 years) patients, all with subfascial wound drain insertion, undergoing multilevel thoracolumbar spine arthrodeses for deformity and degenerative conditions, there was no difference in rate of SSI when 24h of AMP was administered versus continued AMP till wound drain removal (12.4% vs. 13.2% respectively, p=0.48) - In 1 OBS (Kamath) of 226 patients with adolescent idiopathic scoliosis, all with wound drain insertion, undergoing deformity correction surgery, there was no difference in rate of SSI when two postoperative doses of AMP were administered versus continued AMP till wound drain removal (1.94% vs. 1.41% respectively, p=1.0)	High	0	0	-2	0	0	0	0	0	Low	Low	- Evidence downgraded by two grades due to indirectness of the population under study. There are only 2 studies in this evidence-base, with one looking at adolescents (idiopathic scoliosis), and the other looking at adults (>18 years) with idiopathic spinal deformity or degenerative spinal pathologies
	Superficial SSI	1 RCT (Takemoto) 1 OBS (Kamath)	- In 1 RCT (Takemoto), there was a 7.64% (11/147) rate of superficial SSI when AMP use was continued when drain present compared to 8.24% (14/170) when AMP was given for only 24h postoperative regardless of drain presence (no p value calculated). Using Fisher's exact test, we found no significant differences in the rate of deep SSI (p>0.05) - In 1 OBS (Kamath), there was 0 superficial SSI when AMP was continued for entire drain duration, compared to 1 superficial SSI (0.65%) when AMP was not given for entire drain duration (no statistical analysis)	High	0	0	-2	0	0	0	0	0	Low		

	Deep SSI	1 RCT (Takemoto) 1 OBS (Kamath)	- In 1 RCT (Takemoto), there was no significant difference in rate of deep SSI when AMP use was continued when drain present compared to when AMP was given for only 24h postoperative regardless of drain presence (5.56% vs. 4.12%, p=0.60) - In 1 OBS (Kamath), there was 1 deep SSI (1.41%) when AMP was continued for entire drain duration, compared to 2 deep SSI (1.29%) when AMP was not given for entire drain duration (no statistical analysis). Using Fisher's exact test, we found no significant differences in the rate of deep SSI (p>0.05)	High	0	0	-2	0	0	0	0	0	Low		
Q4c. Does early versus late removal of wound drains result in reduced rates of SSI in spine surgery?															
No comparative studies investigated specifically the impact of early versus late removal of drains in the postoperative period and its relationship to rate of SSI															

Domain: 5. Nutrition

Q5a. Does postoperative oral nutritional supplementation reduce the risk of SSI in spine surgery?

Q5b. Does early postoperative parenteral nutrition reduce the risk of SSI in spine surgery?

GRADE Table 5a. 5b

							Decrease GRADE									
Comparison	**Outcome**	**Quantity and Type of Evidence**	**Findings**	**Starting GRADE**	**Study Quality**	**Consistency**	**Directness**	**Precision**	**Publication Bias**	**Large Magnitude**	**Dose-Response**	**Confounders**	**GRADE of evidence for outcome**	**Overall GRADE of evidence base**	**Comments if Up/Downgrade**
Q5a. Does early postoperative oral nutrition reduce the risk of SSI in spine surgery?															
No comparative studies were found investigating if postoperative oral nutritional supplementation reduces the risk of SSI in spine surgery.															
Q5b. Does early postoperative parenteral nutrition reduce the risk of SSI in spine surgery?															
Postoperative total parenteral nutrition (TPN) versus no TPN	SSI	1 RCT (Hu)	In a small RCT (N=35) of patients undergoing staged anterior and posterior instrumented spinal surgery for deformity and degenerative conditions, there was no significant difference in rate of SSI between patients who received postoperative TPN compared to those who did not (18.75% vs. 5.26%, reported as 'not statistically significant', no p value reported by study authors) Using Fisher's exact test, we used data provided in Hu et. al's manuscript and derived a p value of >0.05 (non-significant)	High	0	0	-2	-1	0	0	0	0	Very Low	Very Low	This study was downgraded for the following reasons despite a randomized prospective design: - Downgraded by 1 grade due to indirectness of the evidence with regards to the population studied vis-à-vis the purpose of this review. This RCT looked at a specific subset of spinal surgery patients only (staged anterior-posterior surgery) for deformity or degenerative spine disease. - It was downgraded by a further 1 grade for indirectness with regards to the comparator group: the comparator group commenced oral diet only when bowel sounds returned and flatus occurred postoperatively, a practice which may not reflect contemporary postoperative care. - A further 1 grade was deducted for imprecision secondary to the small samples size of this study

Domain: 6. Clinical Care Pathways

Q6a. Does implementation of infection-specific care pathways reduce the rate of SSI in spine surgery?

Q6b. Do enhanced-recovery after surgery (ERAS) pathways reduce the rate of SSI in spine surgery?

GRADE Table 6a, 6b

								Decrease GRADE				Increase GRADE				
Comparison	**Outcome**	**Quantity and Type of Evidence**	**Findings**	**Starting GRADE**	**Study Quality**	**Consistency**	**Directness**	**Precision**	**Publication Bias**	**Large Magnitude**	**Dose-Response**	**Confounders**	**GRADE of evidence for outcome**	**Overall GRADE of evidence base**	**Comments if UP/DOWNGRADE**
Q6a. Does implementation of infection-specific care pathways reduce the rate of SSI in spine surgery?																
Infection-specific care pathway versus Standard postoperative ward care	SSI	5 OBS (Featherall, Gould, Meyer, Agarwal, Glotzbecker)	- Meta-analysis (N=1686) of 2 OBS (Featherall, Meyer) of adult patients undergoing spinal surgery demonstrates no difference in risk of SSI when a perioperative (pre-, intra-, postoperative) clinical pathway was compared to standard perioperative care: RD= -0.012 (-0.026 to 0.003), p=0.127, I^2=70.27 - All 5 OBS studies utilized different clinical pathways (see Evidence Tables). It is not possible to disambiguate and measure the impact of individual components on SSI rate - In a retrospective cohort study (Agarwal, N=10225) comparing rate of SSI before and after a infection-prevention pathway and physician awareness campaign, there was no significant difference found in rate of SSI between groups. This study was excluded from the above meta-analysis due to unequal distribution of study group numbers and heterogeneity of study population - In a retrospective, two period before-and-after cohort study (Gould, N=224) of pediatric patients undergoing spinal fusion for scoliosis, there was no statistical difference in rate of SSI when an infection prevention pathway was introduced (Pathway care: 2.4% vs Standard care: 8.2%, p=0.695)	Low	0	0	-1	0	0	0	0	0	Very Low	Very Low	Evidence base downgraded by 1 point for indirectness of the intervention with respect to answering the aims of the study. The clinical pathways utilized in the studies were dissimilar from one another.

			- In a retrospective cohort study (Glotzbecker, N=247) of high-risk pediatric patients undergoing multi-level posterior spinal fusion for neuromuscular, syndromic, congenital or idiopathic scoliosis, there was a no significant difference in rate of SSI when a multidisciplinary infection-specific pathway was introduced when compared to pre-pathway standard ward care (6.1% vs. 9.1%, p=0.39)												
	Deep SSI	2 OBS (Meyer, Glotzbecker)	-In a retrospective cohort study designed as a two-period, before and after study of 1935 patients (Meyer), there was a significant (p=0.025) decrease in the rate of deep SSI when an evidence-based infection prevention protocol was instituted over a 12 month period (0% versus 0.57%. The infection prevention bundle consisted of eight evidence-based perioperative measures (See Evidence Table) '- In Glotzbecker et.al's retrospective cohort study (N=247, see above), there was a significant decrease in the rate of deep SSI in high-risk pediatric patients undergoing multi-level posterior spinal fusion (Pathway 0.9% vs. Pre-pathway care 8.3%, p=0.005)	Low	0	-1	0	0	0	0	0	0	Very Low		Evidence base downgraded by 1 point for inconsistency as the definition of a "Deep SSI" was not stated in paper and the manner of how the SSI was diagnosed was not described.
Q6b. Do enhanced-recovery after surgery (ERAS) pathways reduce the rate of SSI in spine surgery?															
ERAS pathway versus Standard postoperative ward care	SSI	4 OBS (Debono, Sivaganesan, Rao, Fletcher)	- Meta-analysis (N=5570) of all 4 OBS demonstrates no difference in risk of SSI when ERAS clinical pathways are utilized in spine surgery; RD= -0.003 (-0.012 to 0.005), p=0.425, I^2=0 - Separate meta-analysis of the 2 OBS on adults (Debono, Sivaganesan) and meta-analysis of the 2 OBS on adolescents (adolescent idiopathic scoliosis) (Rao, Fletcher) similarly demonstrates no statistical differences in rate of SSI when ERAS clinical pathways are utilized - Whilst all 4 OBS adheres to the guiding principles of ERAS, there exists institutional differences in the exact pathway components (see Evidence Tables)	Low	0	0	0	0	0	0	0	0	Low	Low	

Domain: 1. Pharmacologic Measures
Q1. Parenteral Antibiotic Microbial Prophylaxis
Q1a. Does postoperative administration of AMP compared to standard pre-incision antibiotics decrease the risk of SSI in spine surgery?
Q1b. Does 48h of postoperative AMP compared to prolonged (>48h postoperative AMP decrease the risk of SSI in spine surgery?

Evidence Table for Q1a. Does postoperative administration of AMP compared to standard pre-incision antibiotics decrease the risk of SSI in spine surgery?

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Hellbusch 2008 **RCT** **II**	To determine if the postoperative infection rate in instrumented lumbar spinal fusion is affected by postoperative antibiotic use	**No. of patients: n= 233** **Patient Characteristics**: N.R. **Age:** Total range 21-82 (all patients) **Gende**r: Total M: 102, F: 131 **Co-morbidity**: BMI, smoking, previous long-term steroid use, DM, pervious back surgery, previous wound infection was examined during this study. Nil table. Narrative text states "no variables were found to be significant WRT post-op infection rate, several variables showed trend towards significance". Variables "trending towards significance" are: height/weight/BMI, electrophysiologic monitoring, tobacco use, blood transfusion. p = 0.81 to 0.575.	**Intervention Group: n= 116** Extended postoperative protocol received preoperative IV cefazolin + additional 1g cefazolin IV every 8 hours for 3 days followed by 7 days of oral cephalexin 500mg every 6 hours Timing of Intervention: Postoperative Duration of intervention: 10 days Device/agent: 1-2g cefazolin IV and 500mg oral cephalexin Monitoring intervention: N.R.	**SSI (Intervention**): 2 (1.7%) All are superficial infections **SSI (Control):** 5 (4.3%) All are superficial infections **p value**: p>0.25 **Conclusion**: There is no difference in postop SSI rate between the single preop dose and extend dose antibiotic regimen	**Definition of SSI**: N.R. **Distinction between deep and superficial SSI**: Yes **Conflicts of interest**: N.R. **Sample size calculation**: N.R.
		Procedures: 94 TLIF/PLSF 21 PLIF/PLSF 5 ALIF 97 LSF **Indications**: All were for degeneration **Setting**: Non-university medical center **Country**: USA **Dates**: 2002 and 2003	**Control Group: n=117** Single-dose preoperative prophylaxis with cefazolin IV	**Reoperation due to SSI (Intervention):** N.R. **Reoperation due to SSI (Control**): N.R. **p value (reoperation):** N.A.	
		Inclusion criteria: All patients scheduled for instrumented lumber fusion **Exclusion criteria:** Those with cophalosporin allergies or severe penicillin allergies	**Standard perioperative measures:** Preop skin prep: Patients were instructed to shower with chlorhexidine soap the night before and the morning of surgery	**Length of Stay (Intervention):** N.R. **Length of Stay (Control)**: N.R. **p value (LOS):** N.A.	

		Method of case identification: N.R.	Skin Prep: 5-minute Betadine scrub followed by Betadine paint Wound irrigation: All wounds were copiously irrigated with bacitracin solution at the end of the procedure	**Duration follow up**: N.R.	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Dobzyniak 2003 **Retrospective Cohort** **III**	To determine the efficacy of preoperative antibiotics alone in preventing wound infections following lumbar diskectomy.	**No. of patients: n= 610** **Patient Characteristics**: N.R. **Age:** Average patient age = 43 (but does not split into test/control groups) **Gende**r: M: 393/635 F: 243/635 but does not split into test/control groups. 25 patients removed from analysis as no antibiotics documented **Co-morbidity**: Not stated	**Intervention Group: n= 192** Single preoperative antibiotics given in the preoperative holding area or immediately on entering the operating room. Timing of Intervention: Intraoperative and postoperative Duration of intervention: Intraoperatively and postoperatively Device/agent: Antibiotics used for prophylaxis consisted of cephazolin 1 g, Clindamycin 600 mg, Vancomycin 1 g plus clindamycin and Vancomycin 1 g alone Monitoring intervention: NR	**SSI (Intervention**): 3 (1.56%) **SSI (Control):** 5 (1.20%) **p value**: p=0.711 **Conclusion**: There is no difference in postop SSI rate with single pre op or single + at least 3 doses of postop antis	**Definition of SSI**: Positive wound culture or by the attending surgeon's clinical impression **Distinction between deep and superficial SSI**: No **Conflicts of interest**: No conflicts **Sample size calculation**: Yes
		Procedures: Hemilaminotomy and limited discectomy; single or double level **Indications**: Single or double level herniated disc protrusion **Setting**: N.R. **Country**: USA **Dates**: 1993 to March 1999	**Control Group: n=418** Multiple perioperative antibiotic doses with one preoperative and at least three postoperative doses of antibiotics	**Reoperation due to SSI (Intervention):** N.R. **Reoperation due to SSI (Control**): N.R. **p value (reoperation):** N.A.	
		Inclusion criteria: Patients who underwent single or double level herniated disc protrusion by hemilaminotomy and limited discectomy **Exclusion criteria:** N.R. **Method of case identification**: Consecutive	**Standard perioperative measures:** N.R.	**Length of Stay (Intervention):** Average = 2 days (not split into test/control groups) **Length of Stay (Control)**: Average = 2 days (not split into test/control groups) **p value (LOS):** Narrative text states "no clinically significant difference e.g. in LOS"	

				Duration follow up: Retrospective study. Retrospective review of medical records up to 6 weeks post-surgery	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Kakimaru 2010 **Prospective Cohort** **III**	To compare the infection rates following spinal surgery for postoperative Antimicrobial prophylaxis versus no postoperative antimicrobial prophylaxis.	**No. of patients: n= 284** **Patient Characteristics**: N.R. **Age:** Mean 63 **Gende**r: Test=M/F ratio: 89/52 Control=M/F ratio: 94/49 **Co-morbidity**: 15 patients with DM in post-op dose group, vs. 13 patients in no post-op dose. No p value reported. Nil other comorbidities examined.	**Intervention Group: n= 141** Prophylactic IV antibiotic postoperatively after skin closure. This groups consist of 2 separate protocols: 1) Perioperative prophylactic IV antibiotic within 30 minutes before skin incision followed by one dose postop on day of surgery and twice a day IV antibiotic for an average of 2.7 days. 2) Perioperative prophylactic IV antibiotic within 30 minutes before skin incision, followed intraoperative additional IV antibiotic every 3 hours and a single dose IV antis on day of surgery after skin closure Timing of Intervention: Postoperative Duration of intervention: 1-3 days Device/agent: IV antibiotics including cefazolin, flomoxef and piperacillin Monitoring intervention: N.R.	**SSI (Intervention**): 4 (2.8%) 3 superficial 1 deep **SSI (Control):** 2 (1.4%) 2 superficial 0 deep **p value**: p=0.335 **Conclusion**: No significant difference between postop SSI in patients having postop antis or no postop antis	**Definition of SSI**: CDC **Distinction between deep and superficial SSI**: Yes **Conflicts of interest**: No conflicts **Sample size calculation**: N.R.
		Procedures: - Cervical laminoplasty n=88 - lumbar discectomy n=60 - lumbar fenestration n=115 - other n=21 **Indications**: N.R **Setting**: N.R. **Country**: Japan **Dates**: October 2003 to August 2009	**Control Group: n=143** No further antibiotics after skin closure. Perioperative prophylactic IV antibiotic were given within 30 minutes before skin incision, followed intraoperative additional IV antibiotic every 3 hours.	**Reoperation due to SSI (Intervention):** 3/141 (2.1%) **Reoperation due to SSI (Control**): 2/143 (1.4%) **p value (reoperation):** p=0.335	
		Inclusion criteria: All patients who underwent microscopic spinal decompression **Exclusion criteria:** - patients with infectious spondylitis	**Standard perioperative measures:** Perioperative medical review: All patients underwent examination by an internist before admission and received treatment for any abnormalities detected. For patients	**Length of Stay (Intervention):** N.R. **Length of Stay (Control)**: N.R. **p value (LOS):** N.A.	

		- instrumented surgeries **Method of case identification**: N.R.	identified as having diabetes, specialists monitored the serum glucose concentration perioperatively Drains: Suction drains were used in all cases and removed within a few days. Suture removal: sutures at the surgical site were removed 7–10 days after surgery	**Duration follow up**: N.R.	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Kanayama 2007 **Retrospective Cohort** **III**	To compare the rate of SSI in lumbar spine surgeries between two different protocols of AMP	**No. of patients: n= 1597** **Patient Characteristics**: N.R. **Age:** Mean age of study:55.4 **Gende**r: 912 male and 685 female in entire study **Co-morbidity**: N.R.	**Intervention Group: n= 1133** Postoperative antibiotics for 5 to 7 days + preoperative antibiotics (Multiple-dose group) Timing of Intervention: Postoperative Duration of intervention: 5-7 days postoperatively Device/agent: IV cefazolin unless patient had history of significant allergy reaction Monitoring intervention: N.R.	**SSI (Intervention**): Overall: 9 /1133 (0.8%) Fusion: 7/483 Decomp: 2/650 **SSI (Control):** Overall: 2 (0.4%) Fusion:1/182 (0.5%) Decomp: 1 of 282 **p value**: Not significant, no value reported **Conclusion**: There is no difference between single dose antibiotics and postop antis for 5-7 days for reducing SSI	**Definition of SSI**: Post op infection requiring additional surgical intervention **Distinction between deep and superficial SSI**: No **Conflicts of interest**: N.R. **Sample size calculation**: N.R.
		Procedures: - Lumbar decompression - Lumbar instrumented fusion **Indications**: - Lumbar disc herniation: n=686 - Degenerative spondylolisthesis: n-340 - Lumbar spinal stenosis: n=259 - Failed lumbar surgeries: n=73 - Degenerative scoliosis n=52 - Isthmic spondylolisthesis: n=48 - Foraminal stenosis: n=27 - Spinal tumour n=27 - Spinal trauma n=18 - Osteoporotic vertebral collapse n=16 - Others n=51 **Setting**: N.R. **Country**: Japan **Dates**: January 1999 to September 2004	**Control Group: n=464** Perioperative antibiotics only (Single dose group)	**Reoperation due to SSI:** 4 of 11 patients with an infection (including both test and control groups had single episode return to theatre for infection, remaining 7 of 11 patients had multiples return to theatre for infection)	

		Inclusion criteria: All patients undergoing lumbar spine surgery. **Exclusion criteria:** N.R. **Method of case identification**: Consecutive	**Standard perioperative measures:** AMP: Perioperative IV antibiotics (cephazolin unless significant allergy) were given 30 minutes before skin incision. An additional dose was administered every 3hr Ultraclean air: Surgeries were performed in laminar airflow facility Wound irrigation: Surgical site was routinely irrigated using first-generation cephalosporins every hour during surgery Drain: Suction drains were routinely left in posterior spinal wounds where fusions had been performed and were removed 2 to 3 days after the procedure	**Length of Stay (Intervention):** N.R. **Length of Stay (Control)**: N.R. **p value (LOS):** N.A. **Duration follow up**: N.R.	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Lewis 2018 **Retrospective Cohort** **III**	To evaluate the effects of discontinuing postoperative antibiotics (PA) after instrumented spinal surgery by reviewing the rates of SSI, CDI, and growth of resistant bacteria in patients who received postoperative antibiotics in comparison with those who did not	**No. of patients: n= 346** **Patient Characteristics**: Patients in both groups had similar risk factors for SSI, but more non-PA patients had diabetes (29% vs. 14%; p= .001), and more PA patients received postoperative steroids (45% vs. 32%, p = .01). PA patients also had higher estimated blood loss (median of 300cc (IQR 100-500) vs. median of 175cc (IQR 50-400), p = .02). **Age:** Test:62 +/- 14 Control: 62 +/- 12 **Gende**r: Test: M: 92/188 (49%) Control: M: 83/158 (53%) **Co-morbidity**: Co-morbidities examined: BMI, diabetes, prior hardware, pre-op steroids, post-op steroids. Presence of diabetes was great in non-PA patients (46/158 = 29% vs. 26/188 = 14%) with a p value 0.001.	**Intervention Group: n= 188** Intraoperative + Postoperative IV antibiotic Timing of Intervention: Postoperative Duration of intervention: 48 hours postoperatively Device/agent: Postoperative IV cephazolin or vancomycin Monitoring intervention: N.R.	**SSI (Intervention**): 4 (2.0%) 3 Deep 1 Superficial **SSI (Control):** 1 (0.6%) 1 Deep **p value**: p=0.4 **Conclusion**: No difference in postop SSI in patients who did not did not receive postop antis when preop antis were given	**Definition of SSI**: CDC **Distinction between deep and superficial SSI**: Yes **Conflicts of interest**: No conflicts **Sample size calculation**: N.R.
		Procedures: Spinal fusion, no further specification **Indications**: N.R **Setting**: N.R. **Country**: USA	**Control Group: n=158** Intraoperative antibiotics only	**Reoperation due to SSI (Intervention):** N.R. **Reoperation due to SSI (Control**): N.R. **p value (reoperation):** N.A.	

		Dates: March 2015 to October 2016			
		Inclusion criteria: - over Age 17 - have jackson-pratt drain left in place - spinal fusion **Exclusion criteria:** - received antis for any other reason - were given any antibiotic except for cefazolin and vancomycin **Method of case identification**: Consecutive	**Standard perioperative measures:** Preoperative nasal MRSA treatment: Preoperative nasal swabs for methicillin-resistant Staphylococcus aureus (MRSA) and treated with mupirocin nasally if they were MRSA positive Skin prep: Chlorhexidine, AMP: Intravenous antibiotics, Cefazolin was given, unless there was a penicillin allergy or a history of MRSA colonization or infection, in which case vancomycin was used. Drain: All patients included have a Jackson-Pratt drain	**Length of Stay (Intervention):** 4.3 (3.0–6.3) **Length of Stay (Control)**: 4.2 (3.0–6.4) **p value (LOS):** p = 0.8 **Duration follow up**: 90 days	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Numasawa 2015 **Ambispective Cohort** **III**	To investigate the incidence of SSI in patients without administration of antibiotics after spinal instrumentation surgery	**No. of patients: n= 468** **Patient Characteristics**: N.R. **Age:** Test: 51.3+/-20.7 Control: 52.1+/-21.6 **Gende**r: Test: Male: 58.2% Control: Male: 49.1% **Co-morbidity**: N.R.	**Intervention Group: n= 340** Postoperative AMP (Cephazolin 2g/day in adults and 40mg/kg/day in children) intravenously for between 5 and 7 days after spine surgery. No preoperative or intraoperative AMP was used Timing of Intervention: Postoperative Duration of intervention: 5-7 days Device/agent: Intravenous Cefazolin Monitoring intervention: N.R.	**SSI (Intervention**): Overall: 9/340 (2.65%) Superficial: 4/340 (1.18%) Deep: 5/340 (1.47%) Instrumented: 3/147 (2.04%) Non-instrumented: 6/193 (3.11%) **SSI (Control):** Overall: 9/468 (1.92%) Superficial: 7/468 (1.50%) Deep: 2/468 (0.43%) Instrumented: 1/121 (0.83%) Non-instrumented: 8/347 (2.31%) **p value**: p=0.6303 **Conclusion**: No difference in rate of SSI comparing postoperative AMP administration for 5-7 days (in absence of pre&intraoperative AMP) versus pre-incisional/intraoperative AMP only	**Definition of SSI**: - Clinical and lab findings - Signs including purulent exudate, surrounding erythema, wound fluctuance - Lab findings including raised white cell count, C-reactive protein and erythrocyte sedimentation rate - SSI occurring within 30days after the operation if no implant is left in place or within 1 year if implants are placed **Distinction between deep and superficial SSI**: Yes **Conflicts of interest**: N.R. **Sample size calculation**: No

		Procedures: Test: Instrumented spine surgery: 43.2% Non-instrumented surgery: 56.8% Control: Instrumented spine surgery: 25.9% Non-instrumented spine surgery: 74.1% **Indications**: Test - Degenerative disorder: n=275 (58.8%) - Intradural tumour: n=79 (16.9%) - Trauma: n=47 (10%) - Scoliosis: n=44 (9.4%) - Spinal extradural tumours: n=23 (4.9%) Control - Degenerative disorder: n=184 (54.1%) - Intradural tumour: n=54 (15.9%) - Trauma: n=49 (14.4%) - Scoliosis: n=28 (8.2%) - Spinal extradural tumours: n=25 (7.4%) **Setting**: N.R. **Country**: Japan **Dates**: Nov 2003 to Jun 2010	**Control Group: n=486** AMP given preoperative and intraoperatively only (First generation cephalosporin given unless patient had a significant allergy to cephalosporeins. Preoperative AMP given 30min prior to skin incision (AMP redosed intraoperatively every 4 hours)	**Reoperation due to SSI (Intervention):** 3/340 (0.88%) **Reoperation due to SSI (Control)**: 0 **p value (reoperation):** N.R.	
		Inclusion criteria: Spinal surgery **Exclusion criteria:** Pyogenic spondylitis, septic wound condition **Method of case identification**: Consecutive	**Standard perioperative measures:** Preop skin prep: Chlorhexidine wash Wound irrigation: Surgical site was irrigated using only saline solution as often as possible during the surgery, and finally a large amount of saline solution was used before closing the surgical site Drain: Surgical site was managed with continuous negative pressure suction drainage that was removed 48 hours after surgery	**Length of Stay (Intervention):** N.R. **Length of Stay (Control)**: N.R. **p value (LOS):** N.A. **Duration follow up**: At least 1 year follow up	

Evidence Table for Q1b. Does 48h of postoperative AMP compared to prolonged (>48h postoperative AMP decrease the risk of SSI in spine surgery?

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Kim 2010 **Prospective Cohort** **III**	To evaluate the efficacy of a 48 hour antibiotic microbial prophylaxis (AMP) protocol as compared with a 72 hour AMP protocol	**No. of patients: n= 502** **Patient Characteristics**: There were no significant difference between the two groups except for instrumentation and bone grafting. The ratio of instrumented fusion to total surgery was higher in 48-hour antibiotic group and the difference of the ratios between the two groups was statistically significant ($p < 0.01$). **Age:** Test: 58.8 Control: 60.4 **Gende**r: Test: Female: n=173 (61.6%) Control: Female: n=145 (65.6%) **Co-morbidity**: Comorbidities examined: DM, steroid use, immunosuppressant use, smoking, ETOH abuse. None of these are statistically significant between the two groups.	**Intervention Group: n= 281** 48h Antibiotic prophylaxis postop using 1st gen cephalosporins Timing of Intervention: Postoperative Duration of intervention: 48 hours postoperatively Device/agent: 1st gen cephalosporins Monitoring intervention: NR	**SSI (Intervention**): 3 (1.36%) 2 superficial 1 deep **SSI (Control):** 1 (0.36%) **p value**: p=0.325 **Conclusion**: There is no difference in SSI in patients who have had 48h v 72h antibiotic prophylaxis	**Definition of SSI**: CDC **Distinction between deep and superficial SSI**: Yes **Conflicts of interest**: N.R. **Sample size calculation**: N.R.
		Procedures: - Laminectomy/laminoplasty n=58 - Discectomy with laminectomy n=141 - Arthrodesis with instrumentation n=345 - Instrumentation only n=9 **Indications**: N.R. **Setting**: N.R. **Country**: Korea **Dates**: April 2007 to December 2008	**Control Group: n=221** 72h Antibiotic prophylaxis postop using 1st gen cephalosporins	**Reoperation due to SSI (Intervention):** N.R. **Reoperation due to SSI (Control**): N.R. **p value (reoperation):** N.A.	
		Inclusion criteria: N.R. **Exclusion criteria:** N.R. **Method of case identification**: Consecutive	**Standard perioperative measures:** AMP: Perioperative IV antibiotics were given 30 minutes before skin incision. An additional dose was administered every 4hr	**Length of Stay (Intervention):** N.R. **Length of Stay (Control)**: N.R. **p value (LOS):** N.A.	

				Duration follow up: 6 months - however 46 were not follow up until >6 months post-op	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Ohtori 2008 **Retrospective Cohort** **III**	To compare rate of infection, duration of hospital stay, days until normal body temperature, and a panel of blood tests after surgery between long-term and short-term administration of antibiotics for spinal surgery using instrumentation	**No. of patients: n= 135** **Patient Characteristics**: No significant differences were observed between the long-term and short-term groups for surgical time, blood loss, and blood transfusion. **Age:** Average 64.9 **Gende**r: M: 65/135, F: 70/135 **Co-morbidity**: N.R.	**Intervention Group: n=75** Short-term group - Postop antibiotics 2g Cefotiam daily for 2 days Timing of Intervention: Postoperative Duration of intervention: 2 days Device/agent: Intravenous Cefotiam 2g daily Monitoring intervention: N.R.	**SSI (Intervention**): 0 **SSI (Control):** 0 **p value**: N.R. **Conclusion**: No difference in SSI between 2 day and 9 day postop antibiotics	**Definition of SSI**: N.R. **Distinction between deep and superficial SSI**: No **Conflicts of interest**: No conflicts **Sample size calculation**: N.R.
		Procedures: All patients managed with pedicle screw instrumentation and autogenous ICBG (1 level fusion n=45, 2 level fusion n=60, 3 level fusion n=30) **Indications**: - Lumbar canal stenosis with spondylolisthesis - Degenerative scoliosis **Setting**: N.R. **Country**: Japan **Dates**: N.R.	**Control Group: n=60** Long term groups - Postop antibiotics 2g Cefotiam daily for 9 days	**Reoperation due to SSI (Intervention):** N.R. **Reoperation due to SSI (Control**): N.R. **p value (reoperation):** N.A.	
		Inclusion criteria: All lumbar spinal fusions **Exclusion criteria:** Tumour, osteomyelitis, trauma, redo surgeries **Method of case identification**: N.R.	**Standard perioperative measures:** Post op mobility: Patients all started mobilising on postop Day 1 IDC: Indwelling urine catheters removed on postop Day 1 Dressing: Qound dressings were changed on postop Day 2 Drains: Closed suction drains were removed on post op day 2	**Length of Stay (Intervention):** 27.9 +/- 4 **Length of Stay (Control)**: 20.7 +/- 3 **p value (LOS):** $p < 0.05$ **Duration follow up**: N.R.	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Takahashi 2009 **Retrospective Cohort** **III**	To investigate the type of AMP that would be appropriate for spinal surgery and the manner in which it should be used	**No. of patients: n= 876** **Patient Characteristics**: There was a significant difference in the patients' age at the time of the operation for all comparisons, except between groups 2 and 4 and between groups 3 and 4. There was a significant difference in the proportion of patients classified as compromised hosts only between groups 2 and 4. There was a significant difference in the preoperative duration of hospitalization (days) for all comparisons among the groups, except between groups 3 and 4 **Age:** Test: 56.9 Control: 54.8 **Gende**r: 912 male and 685 female in entire study **Co-morbidity**: Rates of diabetes, malignancy, renal failure requiring dialysis and chronic steroid use was recorded. 28.9% of patients receiving 48h of postop AMP had at least one of the above-mentioned comorbidities, whilst 17.0% of the group receiving >48h of AMP had at least one of the above-mentioned comorbidities	**Intervention Group: n=83** Group 4: IV antibiotics at induction and for 2 days postop Antibiotic used was first gen cephalosporin i.e. cefazolin, with initial dose given at anaesthetic induction. Additional doses given every 3h during operation. IV antibiotics was then continued for 2 days after the operation. No oral antibiotics was given Timing of Intervention: Postoperative Duration of intervention: 2 days postoperatively Device/agent: First gen cephalosporin i.e. cefazolin Monitoring intervention: N.R.	**SSI (Intervention**): 0 **SSI (Control):** Total SSI in Group 2+3= 5 (0.9%) Deep n=2 Superficial n=3 **p value**: p>0.05 **Conclusion**: 2 days versus 5 days of postop antis (including antis on induction) was not associated with decreased SSI rates	**Definition of SSI**: CDC **Distinction between deep and superficial SSI**: Yes **Conflicts of interest**: No conflicts **Sample size calculation**: N.R.
		Procedures: N.R. **Indications**: N.R. **Setting**: University hospital **Country**: Japan **Dates**: January 1990 to March 2008	**Control: Group 2 (IV antibiotics at induction and for 5 days postop): n=536** Antibiotic used was first- or second-generation cephalosporin, initial dose given at time of anaesthesia induction, additional dose given when operating time exceeded 5h. After 5 days of IV antis, oral cephalosporin was given orally for 1 week **Control: Group 3 (IV antibiotics at induction and for 3 days postop): n=257** Antibiotic used was first- or second-generation cephalosporin, initial dose given at anaesthetic induction with additional doses every 3h intraoperatively. After 3 days, oral cephalosporin was given orally for 1 week **For meta-analysis, group 2 and group 3 are considered together N=793**	**Reoperation due to SSI (Intervention):** N.R. **Reoperation due to SSI (Control**): N.R. **p value (reoperation):** N.A.	
		Inclusion criteria: Spinal surgery	**Standard perioperative measures:** N.R.	**Length of Stay (Intervention):** N.R.	

		Exclusion criteria: - infectious spondylitis - patients with postoperative infections **Method of case identification**: N.R.		**Length of Stay (Control)**: N.R. **p value (LOS):** N.A. **Duration follow up**: N.R.	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Marimuthu 2016 **RCT** **II**	To compare the efficacy of 24-hour and 72-hour antibiotic prophylaxis in preventing surgical site infections (SSIs)	**No. of patients: n= 326** **Patient Characteristics**: No significant differences were noted between the two groups with regard to sex and comorbidities such as diabetes mellitus, smoking and alcoholism. With regard to the spinal fusion levels, there were no statistically significant differences **Age:** Test: 45.5 Control: 46.5 **Gende**r: Test: Male:Female = 40:116 Control: Male:Female =42:128 **Co-morbidity**: Demographic variables with regard to age, sex, comorbidities (diabetes, smoking, alcoholism) was analysed	**Intervention Group: n=156** 72-hour antibiotic prophylaxis. Prophylactic dosage was initiated at least 30 min before the surgical incision. If the surgical procedure exceeded 3 hour or if the patient required more than 1,000 mL of blood trans¬fusion, an additional perioperative dose of 1 g Cefazolin was administered. Timing of Intervention: Postoperative Duration of intervention: 3 days Device/agent: Intravenous Cefazolin Monitoring intervention: N.R.	**SSI (Intervention**): 4 (2.56%) 1 superficial (0.64%) 3 deep (1.92%) **SSI (Control):** 2 (1.18%) 2 deep (1.18%) **p value**: p=0.43 **Conclusion**: There is no statistical difference in rate of SSI when 24h versus 72h of postoperative AMP is used in spinal fusion surgery	**Definition of SSI**: CDC **Distinction between deep and superficial SSI**: Yes **Conflicts of interest**: No conflicts **Sample size calculation**: No
		Procedures: Spinal fusion with instrumentation Study included subjects with cervical, lumbar, and lumbosacral fusion. No further details specified **Indications**: N.R. **Setting**: University hospital **Country**: India **Dates**: Jun 2012 to Jan 2015	**Control Group: n=170** 24-hour antibiotic prophylaxis. Prophylactic dosage was initiated at least 30 min before the surgical incision. If the surgical procedure exceeded 3 hour or if the patient required more than 1,000 mL of blood trans¬fusion, an additional perioperative dose of 1 g Cefazolin was administered.	**Reoperation due to SSI (Intervention):** 3/156 (1.92%) **Reoperation due to SSI (Control**): 2/170(1.18%) **p value (reoperation):** N.R.	
		Inclusion criteria: Patients >18years old, undergoing instrumented spinal fusion **Exclusion criteria:** Suspected spondylodiscitis, spinal fusion without instrumentation, revision spinal surgery, patients	**Standard perioperative measures:** Drain: The surgical wound in all patients was closed with a suction drain, which was removed after 48 hours.	**Length of Stay (Intervention):** N.R. **Length of Stay (Control)**: N.R. **p value (LOS):** N.A.	

		receiving antibiotics for other infections in the past three weeks **Method of case identification**: N.R.		**Duration follow up**: At least 1 year follow up	

Evidence Table for Q1c. What (non-AMP) pharmacological measures can be used to reduce rate of SSI in spine surgery?

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Inanmaz 2014 **Retrospective Cohort** **III**	To determine beneficiary effects of hyperbaric oxygen treatment in terms of prevention of postoperative deep infection in this specific group of patients in a retrospective	**No. of patients: n= 42** **Patient Characteristics**: There were no significant differences between the groups in terms of the number of fused levels, the amount of intraoperative bleeding, and the duration of operation **Age:** Test: 16.7 (11-27) Control: 15.3 (8–32) **Gende**r: N.R. **Co-morbidity**: Mental retardation: 1 (P-HBO) vs. 2 (control) Prior back surgery: 4 (P-HBO) vs. 5 (control) No p values or other statistical numbers given.	**Intervention Group: n=18** Postoperative hyperbaric oxygen treatment administered at pressure of 2.4 ATA Timing of Intervention: Postoperative Duration of intervention: 90min/day for 30 sessions over 6 weeks (5 sessions/week) Device/agent: Multiplace hyperbaric chamber Monitoring intervention: N.R.	**SSI (Intervention**): 1 (5.5%) **SSI (Control):** 4 (16.6%) **p value**: N.R. **Conclusion**: Prophylactic postop hyperbaric oxygen therapy is associated with reduced incidence of postop SSI in neuromuscular scoliosis patients. This result is not statistically significant	**Definition of SSI**: Defined as infection in which there is a communication between associated infected material and the spinal instrumentation and bone graft/fusion mass **Distinction between deep and superficial SSI**: No **Conflicts of interest**: No conflicts **Sample size calculation**: N.R.
		Procedures: Posterior approach deformity correction with pedicle screws, intralaminar screws, laminar hooks, sublaminar wires and rods, all were Ti A mixture of autograft and allograft cancellous chips were placed for bony fusion **Indications**: Neuromuscular scoliosis **Setting**: University hospital **Country**: Turkey **Dates**: 2006 - 2011	**Control Group: n=24** Standard postoperative care without postoperative hyperbaric oxygen	**Reoperation due to SSI:** Average number of reoperations "was 2.8/infected patient". **p value**: N.R.	
		Inclusion criteria: - presence of scoliosis and/or kyphosis in addition to cerebral palsy or myelomeningocele, - postoperative follow up >1 year - Posterior surgery only **Exclusion criteria:** - patients who did not have enough data in patient file **Method of case identification**: Consecutive	**Standard perioperative measures:** AMP: Antibiotic prophylaxis consisting of 1 g IV Cefazolin 1 hour before surgical incision followed by 1 g IV Cefazolin every 8 hours for 3 days	**Length of Stay (Intervention):** N.R. **Length of Stay (Control)**: N.R. **p value (LOS):** N.A. **Duration follow up**: >1 year	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Demura 2009 **Ambispective Cohort** **III**	To identify independent risk factors for surgical site infection (SSI) and to evaluate the positive effect of prostaglandin E1 (PGE1) to decrease the risk of SSI in patients with spinal metastasis.	**No. of patients: n= 44** **Patient Characteristics**: There were no significant difference between the groups in age, gender, operation time, blood loss amount, total dose of irradiation before surgery, and interval between irradiation and operation **Age:** Test: N.R. Control: 54.1 **Gende**r: Test: N.R. Control: Male=69.2% **Co-morbidity**: N.R.	**Intervention Group: n=22** Intravenous PGE1 administration at 60mcg BD after surgery Timing of Intervention: Postoperative Duration of intervention: 7 days Device/agent: Intravenous PGE1 Monitoring intervention: N.R.	**SSI (Intervention**): 3 (3.19%) All were deep SSI **SSI (Control):** 7 (31.8%) All were deep SSI **p value**: p=0.046 **Conclusion**: PGE1 administration in patients who are receiving preoperative irradiation prior to surgical management of spinal mets is associated with decreased rates of SSI	**Definition of SSI**: N.R **Distinction between deep and superficial SSI**: Yes **Conflicts of interest**: No conflicts **Sample size calculation**: No
		Procedures: - Total enbloc spondylectomy - Debulking surgery with stabilisation - Palliative decompression with stabilization **Indications**: Spinal tumour (mets) **Setting**: N.R. **Country**: Japan **Dates**: Phase I (No PGE1): January 1993 to March 2003 Phase II (PGE1): April 2003 to December 2007	**Control Group: n=22** No PGE1	**Reoperation due to SSI (Intervention):** N.R. **Reoperation due to SSI (Control**): N.R. **p value (reoperation):** N.A.	
		Inclusion criteria: All patients treated surgically for spinal mets who received preoperative irradiation **Exclusion criteria:** N.R. **Method of case identification**: Consecutive	**Standard perioperative measures:** N.R.	**Length of Stay (Intervention):** N.R. **Length of Stay (Control)**: N.R. **p value (LOS):** N.A. **Duration follow up**: N.R.	

Domain: 2. Wound and Dressing Management
Q2a. Is there an optimal type of postoperative dressing that reduces the rate of SSI in spine surgery? (including negative-pressure wound therapy)
Q2b. What is the minimum duration that dressings for uncomplicated wounds should be left intact to reduce the rate of SSI in spine surgery?
Q2c. How much time after surgery should elapse before patients are allowed to wet their wounds e.g. for showering/bathing

Evidence Table for Q2a. Is there an optimal type of postoperative dressing that reduces the rate of SSI in spine surgery? (including negative-pressure wound therapy)

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Epstein 2007 **Retrospective Cohort** **III**	To analyse whether the introduction of silver-impregnated dressing rather than iodine- or alcohol-based swab and dry 4 × 4 gauze would reduce the risk of superficial or deep infection after lumbar laminectomy with instrumented fusion	**No. of patients: n= 234** **Patient Characteristics**: N.R. **Age:** Test: Mean 49.6. Range 23-77 (n=106) Control: Mean 49.14. Range 29-75 (n=128) **Gende**r: Test M: 74/128 = 57.8% F: 54/128 = 42.2% Control M: 51/106 = 48.1% F: 55/106 = 51.9% **Co-morbidity**: Comorbidities examined - DM, HTN, obesity, DVT, prior surgery, depression, coronary disease. Similar numbers between groups except: HTN 2(RD)/16(SD), obesity 15(RD)/29(SD). Nil p values stated.	**Intervention Group: n=106** Silver-impregnated dressings Timing of Intervention: Postoperative Duration of intervention: 2 weeks Device/agent: Silver-impregnated dressings (Silverlon, Argentum, Lakemont GA) Monitoring intervention: N.R.	**SSI (Intervention**): 0/106 **SSI (Control):** Total: 11 (8.59%) Deep: 3 (2.34%) Superficial: 8 (8.59%) **p value**: N.R. **Conclusion**: Use of silver dressings for lumbar laminectomies with instrumented fusions appear to reduce postop SSI	**Definition of SSI**: N.R **Distinction between deep and superficial SSI**: Yes **Conflicts of interest**: N.R **Sample size calculation**: N.R.
		Procedures: Lumbar laminectomy and instrumented fixation and fusion; single and double levels **Indications**: N.R. **Setting**: N.R. **Country**: USA **Dates**: N.R.	**Control Group: n=128** Dressings with Iodine or alcohol swab with a dry 4X4 gauze	**Reoperation due to SSI (Intervention):** 0/106 **Reoperation due to SSI (Control**): 4/128 **p value (reoperation):** N.R.	
		Inclusion criteria: Patients undergoing lumbar-instrumented fusions via posterior approach	**Standard perioperative measures:** N.R.	**Length of Stay (Intervention):** 4.5	

		Exclusion criteria: N.R. **Method of case identification**: N.R.		**Length of Stay (Control)**: 4.8 **p value (LOS):** N.R. **Duration follow up**: Between 1-16 years	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Adogwa 2014 **Retrospective Cohort** **III**	To assess the incidence of wound infection and dehiscence in patients undergoing long-segment thoracolumbar fusion before and after the routine use of negative wound pressure dressings (NPWT)	**No. of patients: n= 160** **Patient Characteristics**: Both cohorts of patients were similar at baseline **Age:** Test: 65.31 +/- 11.19 (n=46) Control: 63.28+/-14.14 (n=114) **Gende**r: Test: Male=34.04% Control: Male=28.07% **Co-morbidity**: No statistical difference in examined comorbidities (BMI, smoking, HTN, DM, ESRD, AKI, CAD, Afib, MI, CHF). Higher % of CAD in NPWT cohort, however p value 0.05. Other comorbidities non-signifcant difference with p values between 0.12-0.85.	**Intervention Group: n=46** Surgical incision was dressed with negative wound pressure dressings (NPWT) after primary wound closure. A continuous negative pressure of -80 mmHg generates uniform negative pressure over the entire incision and draws excess wound fluid from the wound into the dressing Timing of Intervention: Postoperatively Duration of intervention: Removed 3 days postop Device/agent Negative wound pressure dressings Monitoring intervention: NR	**SSI (Intervention**): 5 (10.63%) **SSI (Control):** 17 (14.91%) **p value**: p=0.04 **Conclusion**: Routine NPWT is associated with reduction in postop SSI and wound dehiscence	**Definition of SSI**: CDC **Distinction between deep and superficial SSI**: No **Conflicts of interest**: No conflicts **Sample size calculation**: N.R.
		Procedures: All are TL spine (at any level), instrumented pedicle screw and rod fixation with fusion for deformity **Indications**: TL deformity **Setting**: University hospital **Country**: USA **Dates**: January 2007 to January 2013	**Control Group: n=114** Surgical incision was dressed with xeroform, gauze, and medopore tape after primary wound closure	**Reoperation due to SSI:** RTOR (non-SSI specific) n=6, 12.76% **Reoperation due to SSI (Control**): RTOR (non-SSI specific) n=12, 10.52% **p value (reoperation):** p=0.07	
		Inclusion criteria: All adult patients undergoing posterior TL spinal fusion for deformity, >18 years old, had undergone multilevel ie more than 4 level posterior spinal fusion with pedicle screws and rods at any TL spine level **Exclusion criteria:** Excluded: history of infection at surgical site, severe coexisting comorbidities eg RA, OA, metabolic bone disease, history of immunosuppression, chronic systemic infection, pregnancy	**Standard perioperative measures:** AMP: weight-based IV cefazolin within 1 hour of surgical incision, followed by IV cefazolin every 8 hours for 1 day. If the patient was allergic to penicillin, weight-based IV clindamycin was used instead. Skin prep: All patients were prepared with chlorhexidine Wound irrigation: Before skin closure, irrigation with 3 L of normal saline by pulse lavage was performed	**Length of Stay (Intervention):** 7.29+/-4.26 **Length of Stay (Control)**: 8.08+/-7.00 **p value (LOS):** p = 0.16 **Duration follow up**: N.R.	

		Method of case identification: Consecutive	Closure: Wounds were closed with absorbable suture in the fascia and subcutaneous layers and with staple or suture closure of the skin. After skin closure, incisions were cleaned again with chlorhexidine and a sterile dressing was applied Drains: Subfascial drains were used in all cases. Drains were kept in place until postoperative Day 2 or until drain outputs are less than 80 mL/24 hours.		

Evidence Table for Q2b. What is the minimum duration that dressings for uncomplicated wounds should be left intact to reduce the rate of SSI in spine surgery?

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Bains 2017 **Retrospective Cohort** **III**	To provide an update of dressing change protocol over a 15-year period	**No. of patients: n= 8631** **Patient Characteristics**: N.R. **Age:** Age 18-29: 2.5% Age 30-39: 5.1% Age 40-49: 16% Age 50-59: 25% Age 60-69: 27% Age 70-79: 19% Age 80-89: 5.1% Age >90: 0.3% **Gende**r: Male: 47% Female: 53% **Co-morbidity**: BMI, ASA classification, Smoking history were recorded as a cohort without any statistical analysis between groups	**Intervention Group: n=6158** Dressing protocol of no dressing change for five days after surgery with exception of dressing saturation requiring dressing change Timing of Intervention: Postoperative Duration of intervention: 5 days Device/agent: Dressings Monitoring intervention: N.R.	**SSI (Intervention**): 57 (0.93%) **SSI (Control):** 97 (3.9%) **p value**: p=0.0041. **Conclusion**: Significant decrease in rate of SSI when dressings were not changed for 5 days postoperative as compared to dressing changes occurring at less than 5 days postoperative	**Definition of SSI**: CDC **Distinction between deep and superficial SSI**: No **Conflicts of interest**: No conflicts **Sample size calculation**: No
		Procedures: All spinal fusions Cervical Test: n=1802 Control: n=591 Thoracic Test: n=364 Control: n=102 Lumbar Test: n=3992 Control: n=1780 **Indications**: N.R. **Setting**: State-based Regional Spine Surgery Center **Country**: USA **Dates**: Jan 1999 to Dec 2013	**Control Group: n=2473** Prior to dressing protocol. Variety of postoperative dressing change regimens amongst six surgeons. Most surgeons changed dressings on day 2, some surgeons left dressings on until 2-5 days after surgery, and some removed the dressing whenever postoperative drains were removed	**Reoperation due to SSI (Intervention):** N.R. **Reoperation due to SSI (Control**): N.R. **p value (reoperation):** N.A.	

		Inclusion criteria: All patients who underwent a spine fusion procedure **Exclusion criteria:** Patients younger than 18 years, patients with discitis/osteomyelitis, epidural abscess **Method of case identification**: ICD 9 Procedure codes for spine arthrodesis and/or instrumentation	**Standard perioperative measures:** Preop skin prep: Chlorhexidine wash (Hibiclens; M€olnlycke Health Care, Norcross, GA) of the surgical site on the night before and morning of surgery. AMP: All patients receive preoperative intravenous antibiotics consisting of Cefazolin - a first-generation cephalosporin. In patients with an allergy to cephalosporins, vancomycin is used. All patients have antibiotics redosed intraoperatively every 3 to 4 hours. All intravenous antibiotics are discontinued 48 hours after surgery or earlier if the patient is discharged within 48 hours. Wound irrigation: Copious wound irrigation with normal saline antibiotic solution containing 50,000 units of bacitracin in 3 L of normal saline. Local AMP: Local, intrawound antibiotic delivery (deep and subcutaneous) with vancomycin powder (this is a recent infection control measure instituted by our team in January 2014). Closure: Meticulous, layered wound closure. Drain: Closed suction drains are routinely used. Drains are generally removed 1 to 3 days after surgery, while the dressing on the wound is kept intact. Dressings: Bacitracin ointment over the wound. Iodine-impregnated 1-inch Steri-Strips (3M, St Paul, MN) applied on top of the ointment. Sterile dressing using gas-permeable barrier (Tegaderm; 3M).	**Length of Stay (Intervention):** N.R. **Length of Stay (Control)**: N.R. **p value (LOS):** N.A. **Duration follow up**: N.R.	

Evidence Table for Q2c. How much time after surgery should elapse before patients are allowed to wet their wounds e.g. for showering/bathing

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Carragee 1996 **Ambispective Cohort** **III**	To determine if early bathing after posterior spinal surgery resulted in increased wound problems.	**No. of patients: n= 192** **Patient Characteristics**: The two groups have similar characteristics except operative time and patient complexity (revisions and instrumented fusion) were increased in early bathing group **Age:** Case: 44.9 Control: 48.4 **Gende**r: Case=M:F 64:36 Control=M:F 71:29 **Co-morbidity**: No statistical difference between groups in age or gender	**Intervention Group: n=97** Early bathing group - Allowed to shower and wet the wound 2-5 days postoperatively (prior to removal of staples). Patients were instructed to dry and re-cover the wound with a sterile gauze after showering. - Lumbar microdiscectomy patients: shower after 2 days - All other patients encouraged to wait until 5 days postoperatively Timing of Intervention: Postoperative Duration of intervention: 2-5 days Monitoring intervention: N.R.	**SSI (Intervention**): Overall: 2 (2.06%) 0 Deep 2 Superficial **SSI (Control):** Overall 4 (4.21%) 1 Deep 3 Superficial **p value**: N.R. **Conclusion**: In uncomplicated posterior spinal surgery when skin staples are applied, early bathing 2-5 days after surgery did not increase the risk of wound problems	**Definition of SSI**: N.R **Distinction between deep and superficial SSI**: Yes **Conflicts of interest**: N.R **Sample size calculation**: No
		Procedures: Posterior thoracolumbar spine surgery, included decompression, instrumented and non-instrumented fusion surgery **Indications**: N.R. **Setting**: University hospital **Country**: USA **Dates**: Before and after 1992, exact time frame not reported	**Control Group: n=95** Late bathing group - showers prohibited until removal of staples at 10 - 16 days postoperatively	**Reoperation due to SSI (Intervention):** N.R. **Reoperation due to SSI (Control**): N.R. **p value (reoperation):** N.A.	
		Inclusion criteria: Patients undergoing posterior surgery in the thoracolumbar spine **Exclusion criteria:** Previous irradiation of area, previous wound or current spinal infection, planned or incidental durotomy, wound not closed with skin staples, patients with immunocompromised states e.g. chemotherapy, long-term steroids, patients requiring rotational or free flap coverage **Method of case identification**: N.R.	**Standard perioperative measures:** AMP: Prophylaxis antibiotics intravenous Cefazolin 1g were given immediately before incision. Penicillin-allergic patients were given vancomycin. No additional antibiotics were administered unless instrumentation was implanted, in which case the antibiotics were continued for at least 24 hours (1-5 days, depending on how long drains were left in place) Wound closure: Steel skin staples	**Length of Stay (Intervention):** N.R. **Length of Stay (Control)**: N.R. **p value (LOS):** N.A. **Duration follow up**: 22 months	

Domain: 4. Drain Tube Management
Q4a. Does usage of a wound drain alter the risk of SSI in spine surgery?
Q4b. Does concomitant administration of AMP in the presence of a wound drain reduce the rate of SSI in spine surgery?
Q4c. Does early versus late removal of wound drains result in reduced rates of SSI in spine surgery?

Evidence Table for Q4a. Does usage of a wound drain alter the risk of SSI in spine surgery?

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Blank 2003 **RCT** **II**	To assess the impact of closed suction drainage on transfusion requirements, frequency of dressing changes, and wound healing following posterior spinal fusion in adolescents with idiopathic scoliosis surgery	**No. of patients: n= 30** **Patient Characteristics**: N.R. **Age:** Test: 14.4 (n=18) Control:13.25 (n=12) **Gende**r: N.R. **Co-morbidity**: N.R.	**Intervention Group: n=18** Drain was placed between the closed fascia and the subcutaneous tissues and tunneled 2-4 cm under the skin. The drains were attached to a closed suction reservoir Timing of Intervention: Intraoperatively Duration of intervention: Removed 48 hours postop Device/agent: Subcutaneous closed suction drain tube Monitoring intervention: Dressings were examined postoperatively at 4, 12, 24, and 48 hours and graded based on the amount of saturation. At discharge, the wounds were graded as follows: excellent (complete closure with minimal, clear, or no drainage), fair (separation of the wound edges or excessive drainage), or complicated (large wound hematoma or infection).	**SSI (Intervention**): 0 (0%) **SSI (Control):** 3/12 (25%) **p value**: N.R. **Conclusion**: Subcutaneous closed suction drainage can imrpove immediate postoperative wound saturation and does not cause increased SSI	**Definition of SSI**: N.R. **Distinction between deep and superficial SSI**: N.R. **Conflicts of interest**: N.R. **Sample size calculation**: N.R.
		Procedures: Scoliosis correction with posterior pedicle screws, hooks, double rod system **Indications**: Progressive idiopathic scoliosis **Setting**: N.R. **Country**: USA **Dates**: N.R.	**Control Group: n=12** Standard closure with no drain tube	**Reoperation due to SSI (Intervention):** 0 (0%). **Reoperation due to SSI (Control**): 3/12 (25%) **p value (reoperation):** N.R.	
		Inclusion criteria: All adolescent patients (under 18 years old) undergoing posterior spinal fusion and instrumentation for progressive idiopathic scoliosis **Exclusion criteria:** N.R.	**Standard perioperative measures:** AMP: All patients received a prophylactic, 48-hour course of cephalosporin beginning intraoperatively	**Length of Stay (Intervention):** N.R. **Length of Stay (Control)**: N.R. **p value (LOS):** N.A.	

		Method of case identification: Consecutive		**Duration follow up**: N.R.	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Brown 2004 **RCT** **II**	To study the risk of infection, hematoma, and neurologic deficits following extensive lumbar spine surgery in patients with or without prophylactic closed wound suction drain placement	**No. of patients: n= 83** **Patient Characteristics**: No significant differences existed between the drain and no drain patients in the variables age, operating room time, estimated blood loss, hemoglobin and hematocrit levels, or length of hospital stay **Age:** Test:67.40 (n=42) Control:67.44 (n=41) **Gende**r: N.R. **Co-morbidity**: N.R.	**Intervention Group: n=42** Closed wound suction drain placed below the deep fascia, over the exposed dura before wound closure Timing of Intervention: Intraoperatively Duration of intervention: Postoperatively Device/agent: Subfascial closed suction drain tube Monitoring intervention: N.R.	**SSI (Intervention**): 0 (0%) **SSI (Control):** 0 (0%) **p value**: N.A. **Conclusion**: Closed suction wound drainage versus no drainage does not result in differences in postop SSI or postop wound hematoma	**Definition of SSI**: N.R. **Distinction between deep and superficial SSI**: N.R. **Conflicts of interest**: No conflicts **Sample size calculation**: N.R.
		Procedures: - Multilevel decompression - Redo lumbar decompression - Decompression and instrumented fixation and fusion - Decompression and non-instrumented fusion **Indications**: - Disc protrusion - spinal lumbar stenosis - degenerative spondylolisthesis - post-laminectomy syndrome **Setting**: N.R. **Country**: USA **Dates**: N.R.	**Control Group: n=41** Standard closure with no drain tube	**Reoperation due to SSI (Intervention):** N.R. **Reoperation due to SSI (Control**): N.R. **p value (reoperation):** N.A.	
		Inclusion criteria: All patients undergoing more extensive lumbar spine surgery than single-level unilateral decompression **Exclusion criteria:** Incidental durotomy **Method of case identification**: Consecutive	**Standard perioperative measures:** N.R.	**Length of Stay (Intervention):** 3.32 **Length of Stay (Control)**: 3.92 **p value (LOS):** p = 0.1774 **Duration follow up**: N.R.	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Payne 1996 **RCT** **II**	To determine efficacy of prophylactic wound suction drainage after single level lumbar laminectomy	**No. of patients: n= 200** **Patient Characteristics**: N.R. **Age:** N.R. **Gende**r: N.R. **Co-morbidity**: No patient in either group had a comorbid condition leading to immunosuppression", except "single patient with DM"	**Intervention Group: n=103** Closed suction wound drain placed subfascially. Timing of Intervention: Intraoperative Duration of intervention: All drains were removed on 2nd postoperative day Device/agent: Subfascial closed suction wound drain Monitoring intervention: N.R.	**SSI (Intervention**): 2 (1.94%) **SSI (Control):** 1 (1.03%) **p value**: p=0.429 **Conclusion**: No difference in SSI between presence or absence of wound drainage	**Definition of SSI**: N.R. **Distinction between deep and superficial SSI**: No **Conflicts of interest**: N.R. **Sample size calculation**: N.R.
		Procedures: - Single level hemilaminectomy - Single level lumbar laminectomy **Indications**: - Herniated disc protrusion - Lumbar degenerative stenosis **Setting**: N.R. **Country**: USA **Dates**: N.R.	**Control Group: n=97** No wound drain	**Reoperation due to SSI (Intervention):** 0/103 **Reoperation due to SSI (Control**): 1/97 = 1% **p value (reoperation):** N.R.	
		Inclusion criteria: Patients undergoing single level lumbar hemilaminectomy for herniated disc or decompressive lumbar laminectomy for degenerative stenosis **Exclusion criteria:** N.R. **Method of case identification**: Consecutive	**Standard perioperative measures:** AMP: All patients had antibiotic prophylaxis just before and for 48h after surgery. DVT prophylaxis: All patients received venous thrombosis with elastic stockings or penumatic compressive devices. NSAIDS: No aspirin or NSAIDs used in the immediate postoperative phase. Discharge: Patients discharged between 2nd and 3rd postoperative day	**Length of Stay (Intervention):** N.R. **Length of Stay (Control)**: N.R. **p value (LOS):** N.A. **Duration follow up**: Follow up between 8-14 days after surgery. Wounds evaluated at this time for haematoma and/or infection. If infection suspected, wound culture sent, oral ABx started. If not responsive to oral ABx, then admitted to hospital for IV ABx and I+D of wound	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Gubin 2018 **RCT** **II**	To explore the role of closed suction drain in multi-level posterior spinal surgery	**No. of patients: n= 155** **Patient Characteristics:** Both groups were comparable with regard to demographic, clinical characteristics and indication for surgery and the nature of spinal surgeries performed. The "drain" group had longer duration of surgeries and larger area of surgical wounds (length of the incision multiplied by the depth of the wound, both in millimetres), which was statistically significant. Intraoperative blood loss in both groups was comparable **Age:** Test: 48.4+/-16.6 Control: 47.9+/-16.6 **Gende**r: Test=Male: 41.3% Control=Male: 41.3% **Co-morbidity**: Patient weight, hypertension status, diabetes and obesity were recorded. There were no statistical differences between the above demographic factors (p>0.05 for all).	**Intervention Group: n=80** Standard closure with two drains—one in the epidural space and one in paraspinal area exiting through separate stab incisions and connected to a common suction bulb Timing of Intervention: Intraoperative Duration of intervention: Postoperatively Device/agent: Closed suction drain tube Monitoring intervention: Wounds were inspected and dressed once daily for the first 3 days and thereafter just before discharge from the hospital. The wounds were examined for any evidence of collection (as evidenced by fluctuant swelling) and if present were aspirated with a wide-bore needle under all aseptic precautions	**SSI (Intervention**): 1 (1.25%) **SSI (Control):** 1 (1.3%) **p value**: N.R. **Conclusion**: No difference in terms of SSI in drain and 'no drain' group	**Definition of SSI**: N.R. **Distinction between deep and superficial SSI**: No **Conflicts of interest**: No conflicts **Sample size calculation**: N.R.
		Procedures: Posterior spinal surgery of two or more motion segments **Indications**: Trauma, spinal canal stenosis, spondylolisthesis, deformity or tumour **Setting**: Tertiary teaching hospital **Country**: Russia **Dates**: Oct 2015 to Jun 2017	**Control Group: n=75** Standard closure with no drain tube	**Reoperation due to SSI (Intervention):** 0 **Reoperation due to SSI (Control**): 0 **p value (reoperation):** N.A.	
		Inclusion criteria: Skeletally mature patients, posterior spinal surgery for any reason (trauma, spinal canal stenosis, spondylolisthesis, deformity or tumour), willingness to participate in study **Exclusion criteria:** Posterior spinal surgery invovling single level (where drains are not normally used), non-posterior approach, infectious pathology e.g. discitis, coagulopathy or bleeding disorders, history of treatment with antiplatelet drugs and/or anticoagulants	**Standard perioperative measures:** Surgeon: All patients enrolled into the study were operated by three consultant spine surgeons of the same level of qualification and experience Suture removal: Sutures were removed at 2 weeks in the out-patient department	**Length of Stay (Intervention):** N.R. **Length of Stay (Control)**: N.R. **p value (LOS):** N.A. **Duration follow up**: At least 6 weeks follow up. Clinical follow up to 6 months for most patients for functional scores	

		Method of case identification: Trial randomization			

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Hung 2017 **RCT** **II**	To evaluate if closed suction wound drainage is necessary in minimally invasive surgery of transforaminal lumbar interbody fusion (MIS TLIF).	**No. of patients: n= 56** **Patient Characteristics:** Age, sex, BMI, levels of surgery and underlying medical condition (diabetes mellitus, under anticoagulation therapy for cerebrovascular events or heart disease, and smoking) showed no significant difference between the two groups. **Age:** Test: 63.2+/-12 Control: 62+/-15 **Gende**r: Test: Female: 64% Control: Female: 64% **Co-morbidity**: Age, gender, BMI, diabetes mellitus, presence of anticoagulation therapy, smoking were recorded and compared. There was no statistically significant differences in the above variables (all p>0.05).	**Intervention Group: n=28** Drain (Hemovac) inserted in the epidural space (subfascial). Timing of Intervention: Intraoperative Duration of intervention: Drains were removed on postoperative Day 2 Device/agent: Subfascial drain tube (Hemovac) Monitoring intervention: N.R.	**SSI (Intervention**): 2 (7.14%) Superficial: 2 Deep: 0 **SSI (Control):** 1 (3.57%) Superficial: 1 Deep: 0 **p value**: p>0.999 **Conclusion**: There is no difference in rate of SSI in MIS TLIF when drain is used versus when no drain is used	**Definition of SSI**: N.R. **Distinction between deep and superficial SSI**: Yes **Conflicts of interest**: No conflicts **Sample size calculation**: No
		Procedures: MIS TLIF with percutaneous pedicle screw insertion, midline unilateral approach for bilateral deompression and interbody fusion with PEEK cage via TLIF approach. **Indications**: Grade I spondylolisthesis, pars fractures, degnerative disc disease with back pain or radiculopathy involving one or two segments **Setting**: N.R. **Country**: Taiwan, ROC **Dates**: May 2012 to Jun 2013	**Control Group: n=28** No drain	**Reoperation due to SSI (Intervention):** 0 **Reoperation due to SSI (Control**): 0 **p value (reoperation):** N.A.	
		Inclusion criteria: Patients undergoing MIS TLIF, pathology from L1 to S1 **Exclusion criteria:** Previous spine surgery, systemic autoimmune disease, end stage renal failure, Parkinson's disease	**Standard perioperative measures:** N.R.	**Length of Stay (Intervention):** 7.5 **Length of Stay (Control)**: 6.7 **p value (LOS):** 0.137	

		Method of case identification: Randomized with computer-generated random numbers		**Duration follow up**: 25.3 months	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Diab 2012 **Retrospective Cohort** **III**	To evaluate outcomes of closed-suction wound drainage after posterior spinal fusion with instrumentation for adolescent idiopathic scoliosis and to identify surgeon patterns of drain use in this cohort.	**No. of patients: n= 500** **Patient Characteristics:** There were no differences in age, sex, or body mass index between cohorts. Curve type differed between the groups (not statistical significance). Type of instrumentation differed by drain status: 90% (164 of 182) of patients with all pedicle screws received drains as compared with 53% (153 of 291) of patients with hybrid constructs (wires and hooks with or without screws) and 30% (7 of 23) of patients with all hook constructs (P < 0.001). Drained patients had less mean operative time (275.8 ± 80.6 min vs. 306.9 ± 78.1 min, P < 0.001) and more fusion levels (11.7 ± 2.3 vs. 11.2 ± 2.4, P = 0.02). Rate of thoracoplasty did not differ significantly between groups (10% of drained patients vs. 6% of undrained patients; P = 0.223). **Age:** Test: 15.7+/-1.6 (n=324) Control: 15.6+/-1.7 **Gende**r: Test: F=262/321 (81.6%) Control: F=133/176 (75.6%) **Co-morbidity**: N.R.	**Intervention Group: n=324** Wound drainage (subfascial, subcutaneous or combined) Timing of Intervention: Intraoperative Duration of intervention: Postoperatively Device/agent: Wound drain Monitoring intervention: N.R.	**SSI (Intervention**): 5 (1.5%) **SSI (Control):** 3 (1.7%) **p value**: p>0.99 **Conclusion**: Wound drainage did not impact upon postop SSI rate or rate of general infections postop	**Definition of SSI**: N.R. **Distinction between deep and superficial SSI**: No **Conflicts of interest**: No conflicts **Sample size calculation**: N.R.
		Procedures: Deformity correction with either pedicles screws only, hybrid constructs ie wires and hooks with or without screws, hook construct only, no complex osteotomies or vertebral column resections performed **Indications**: Late onset adolescent idiopathic scoliosis **Setting**: Multicenter spinal deformity study group **Country**: USA, Canada, Europe **Dates**: 2003 - 2010	**Control Group: n=176** No wound drainage	**Reoperation due to SSI (Intervention):** RTOR 4/324. Note: unclear what reason for going back to OR, does not specify if all due to infections or other causes. **Reoperation due to SSI (Control**): RTOR 4/176. Note: unclear what reason for going back to OR, does not specify if all due to infections or other causes. **p value (reoperation):** p>0.05	

		Inclusion criteria: Thoracic, thoracolumbar, lumbar idiopathic scoliosis in patients aged 8 to 18 yrs at diagnosis and younger than 21 yrs, primary procedure, posterior approach only, mimimum 2 years follow up **Exclusion criteria:** Younger than 13 years at surgery, pts with Risser grade <3 at operation **Method of case identification**: Consecutive	**Standard perioperative measures:** N.R.	**Length of Stay:** Average = 5.85 (not split into test/control groups) **Duration follow up**: Minimum 2 years	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Sen 2005 **Retrospective Cohort** **III**	To evaluate for postoperative epidural fibrosis, postoperative pain scales and scores, in two groups. One group had closed suction drains, and the other group did not.	**No. of patients: n= 79** **Patient Characteristics:** N.R. **Age:** Mean age: 46.44 years (range, 23–82; SD, 10.9). **Gende**r: Total M/F ratio: 45/34 **Co-morbidity**: States "Past medical histories of all patients were unremarkable for hematologic or metabolic disorders. There was no other active disease."	**Intervention Group: n=41** Closed wound drainage - 2cm drain with 8 side holes, free drainage with gravity (no suction) Timing of Intervention: Intraoperative Duration of intervention: Drain maintained for 12h postop and then removed Device/agent: Subfascial closed suction wound drain Monitoring intervention: N.R.	**SSI (Intervention**): 0 **SSI (Control):** 0 **p value**: N.A. **Conclusion**: No difference in infection rate with or without closed suction drainage	**Definition of SSI**: N.R. **Distinction between deep and superficial SSI**: No **Conflicts of interest**: N.R. **Sample size calculation**: N.R.
		Procedures: N.R. **Indications**: - Disc protrusion - Disc extrusion **Setting**: N.R. **Country**: Turkey **Dates**: N.R.	**Control Group: n=38** No wound drain	**Reoperation due to SSI (Intervention):** 0 **Reoperation due to SSI (Control**): 0 **p value (reoperation):** N.A.	
		Inclusion criteria: Patients undergoing surgery for single level lumbar disc herniation **Exclusion criteria:** Spinal stenosis, infective spondylitis, lateral recess disease, neoplastic disease, thickened ligamentum flavum **Method of case identification**: N.R.	**Standard perioperative measures:** Surgeon: All patients operated on by same surgeon AMP: Systemic prophylactic antibiotic therapy with cephazolin was given intravenously in a doage of 1g at 2h before surgery, and 1g every 6h postoperatively to a maximum of 3 doses.	**Length of Stay (Intervention):** N.R. **Length of Stay (Control)**: N.R. **p value (LOS):** N.A. **Duration follow up**: N.R.	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Sohn 2013 **Retrospective Cohort** **III**	To investigate whether closed suction wound drainage is essential after primary intradural spinal cord tumour surgery	**No. of patients: n= 169** **Patient Characteristics:** Distribution of sex was not different between the groups while mean age in group without drain was older. Height, weight, BMI, the number of laminectomy levels, proportion of laminectomy vs laminoplasty, amount of operation time, mean estimated intraoperative blood loss were not different between the groups **Age:** Test: 46.20 ± 15.63 y Control: 51.05 ± 14.89 y **Gende**r: Test: M:F = 39:36 Control: M:F = 46:48 **Co-morbidity**: BMI	**Intervention Group: n=75** Subfascial closed suction drainage inserted for 1-3 days postop. Insertion was approximately 2-3cm below surgical skin incision and connected to a 400cm^3 bag equipped with a spring to generate negative pressure Timing of Intervention: Intraoperative Duration of intervention: Drain maintained for 1-3 days. The bag and drain were removed if the daily amount drained was less than 50 cm3. If CSF appeared in the drain tube or bag, the tube was clamped and removed Device/agent: Subfascial silicone closed suction drain Monitoring intervention: The surgical wound was closely observed every day, beginning on the second postoperative day. If CSF leakage through the skin wound was suspected, the leakage point was sutured with nylon or staples.	**SSI (Intervention)**: 2 (2.67%) **SSI (Control):** 0 **p value**: p=0.20 **Conclusion**: Closed suction drainage is not associated with decreased rates of SSI in primary intradury surgery	**Definition of SSI**: Clinician assessment **Distinction between deep and superficial SSI**: No **Conflicts of interest**: No conflicts **Sample size calculation**: N.R.
		Procedures: - Prone - Laminectomy and durotomy - removal of intradural tumour - lamina replaced with mini-plate or translaminar screw if possible **Indications**: - Meningioma - Schwannoma - Neurofibroma - Ependymoma - Hemangioblastoma - Glioneuronal tumour **Setting**: N.R. **Country**: Korea **Dates**: January 2003 to October 2011	**Control Group: n=94** No drainage	**Reoperation due to SSI (Intervention):** 2/75 = 2.7% **Reoperation due to SSI (Control**): 0/94 **p value (reoperation):** p = 0.20.	
		Inclusion criteria: Primary intraudural spinal cord tumours **Exclusion criteria:** - non-ambulatory patients	**Standard perioperative measures:** Wound closure: Arachnoid membrane closed by 8-0 nylon; dural closure watertight with 4-0 silk with interrupted suture, fibrin bioglue used. Multulayered muscle, fascia	**Length of Stay (Intervention):** 9.25 +/- 5.01 **Length of Stay (Control)**: 9.35 +/- 5.75	

		- bleeding diathesis - revision surgery due to recurrent or residual tumour **Method of case identification:** Consecutive	skin closure. If watertight primary closure not possible, supplementary muscle or artificial dural patch graft was used AMP: Prophylactic antibiotics with first generation cephalosporin were given to each patient once, beginning 1 h before incision and was continued for 24 h postoperatively Mobility: All patients were encouraged to ambulate from the day of the operation	**p value (LOS):** p = 0.91 **Duration follow up**: N.R.	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Walid 2012 **Retrospective Cohort** **III**	To study the role of drains in lumbar spine fusions	**No. of patients: n= 402** **Patient Characteristics:** N.R. **Age:** Mean age: 57.3 years **Gende**r: N.R. **Co-morbidity**: DM = 29.1% of patients. BMI on average was 31.3 with SD 6.8. However no indication of the split between the cohort groups.	**Intervention Group: n=285** Closed suction drain Timing of Intervention: Intraoperative Duration of intervention: Postoperatively Device/agent: Closed suction drain Monitoring intervention: N.R.	**SSI (Intervention**): 10 (3.5%) **SSI (Control):** 3 (2.6%) **p value**: p=0.627 **Conclusion**: Drains did not increase the risk of SSI in patients undergoing lumbar decompression and fusion	**Definition of SSI**: N.R. **Distinction between deep and superficial SSI**: No **Conflicts of interest**: No conflicts **Sample size calculation**: N.R.
		Procedures: Posterior lumbar decompression and fusion **Indications**: - lumbosacral spondylosis - lumbar disc displacement - lumbar disc degeneration - lumbar spinal stenosis - Spondylolisthesis **Setting**: N.R. **Country**: USA **Dates**: October 2007 to September 2009	**Control Group: n=117** No drain	**Reoperation due to SSI (Intervention):** N.R. **Reoperation due to SSI (Control**): N.R. **p value (reoperation):** N.A.	
		Inclusion criteria: Patients undergoing lumbar decompression with posterior or posterolateral fusion **Exclusion criteria:** N.R.	**Standard perioperative measures:** AMP: All patients received infection prophylaxis: Patients weighing <80 kg: cefazolin 1g; Patients weighing >80 kg: cefazolin 2 g; Patients with cefazolin allergy: vancomycin 15 mg/kg IV over 1 hour	**Length of Stay (Intervention):** N.R. **Length of Stay (Control)**: N.R. **p value (LOS):** N.A.	

		Method of case identification: ICD Coding		**Duration follow up**: N.R.	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Kanayama 2010 **Retrospective Cohort** **III**	To evaluate efficacy of closed suction drainage in single level lumbar decompression	**No. of patients: n= 560** **Patient Characteristics:** Mean operating time (55 and 56 minutes) and intraoperative blood loss (64 and 57 mL) were similar in both groups. **Age:** Test: 44 Control: 48 **Gende**r: M:F ratio Test: 190:108 Control: 168:94 **Co-morbidity**: N.R.	**Intervention Group: n=298** Closed suction drain. No information on location of drain Timing of Intervention: Intraoperative Duration of intervention: The drain was removed when the amount of bleeding did not exceed 50 mL per day Device/agent: Closed suction drain tube Monitoring intervention: N.R.	**SSI (Intervention**): 0 **SSI (Control):** 0 **p value**: N.A. **Conclusion**: No difference in risk of SSI with or without closed suction wound drain	**Definition of SSI**: N.R. **Distinction between deep and superficial SSI**: No **Conflicts of interest**: No conflicts **Sample size calculation**: No
		Procedures: Single-level lumbar laminoplasty or discectomy **Indications**: N.R. **Setting**: N.R. **Country**: Japan **Dates**: January 2001 to October 2005	**Control Group: n=262** No Drain	**Reoperation due to SSI (Intervention):** 0 **Reoperation due to SSI (Control**): 0 **p value (reoperation):** N.A.	
		Inclusion criteria: Single level lumbar decompression **Exclusion criteria:** N.R. **Method of case identification:** Consecutive	**Standard perioperative measures:** AMP: Until Dec 2002, IV antibiotics used for 5-7 days postoperatively. From Jan 2003, antibiotics given only on day of surgery. First generation cephalosporin was used unless contraindicated. Anesthetics: Surgery performed under hypotensive anaesthesia. Before wound closure, blood pressure was returned to normotension Haemostosis: Substantial epidural bleeding, if any, was stopped using electrocautery. Fibrin glue applied on epidural space after hemostasis.	**Length of Stay (Intervention):** N.R. **Length of Stay (Control)**: N.R. **p value (LOS):** N.A. **Duration follow up**: N.R.	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Adogwa 2018 **Retrospective Cohort** **III**	To determine the incidence of post-operative complications after spinal decompression and fusion with and without a subfascial drain	**No. of patients: n= 139** **Patient Characteristics:** There were no significant differences in baseline demographics and co-morbidities between both groups. The mean BMI was significantly higher in the drain-use cohort. Intraoperative variables were similar except drain-Use cohort had significantly higher intraoperative blood loss **Age:** Test: 64.9+/-11.0 Control: 65.0+/-10.6 **Gende**r: Test: Male 42.2% Control: Male: 47.8% **Co-morbidity**: Preoperative variables in terms of depression, anxiety, congestive heart failure, coronary artery disease, atrial fibrillation, peripheral vascular disease, myocardic infarction history, hypertension, diabetes, DVT, hyperlipidemia, pulmonary embolisem and anemia were compared between groups. BMI was higher (p=0.02) in the drain group	**Intervention Group: n=139** Placement of subfascial drain tube. Timing of Intervention: Intraoperatively Duration of intervention: Postoperatively Device/agent: Drain tube Monitoring intervention: N.R.	**SSI (Intervention)**: Total: 3 (2.59%) Deep: 2 (1.7%_ Superficial: 1 (0.9%) **SSI (Control):** Total: 0 Deep: 0 Superficial: 0 **p value**: Deep: p=0.52 Superficial: p=0.66 **Conclusion**: No difference in terms of SSI in drain and 'no drain' group	**Definition of SSI**: N.R. **Distinction between deep and superficial SSI**: Yes **Conflicts of interest**: No conflicts **Sample size calculation**: No
		Procedures: Spinal deformity for elective decompression and fusion: - Median number of levels fused: 3 - Median number of laminectomy levels: 2 **Indications**: Spinal deformity for elective decompression and fusion **Setting**: Major academic institution **Country**: USA **Dates**: N.R.	**Control Group: n=23** Standard closure with no drain tube	**Reoperation due to SSI (Intervention):** N.R. **Reoperation due to SSI (Control)**: N.R. **p value (reoperation):** N.A.	
		Inclusion criteria: >18 years old, with spinal deformity undergoing elective spinal decompression and fusion, has available demographics and treatment data, had presence or absence of a drain documented on medical records **Exclusion criteria:** N.R.	**Standard perioperative measures:** N.R.	**Length of Stay (Intervention):** 5.0+/-2.7 **Length of Stay (Control)**: 2.8+/-1.5 **p value (LOS):** p<0.0001	

		Method of case identification: Retrospective chart review		**Duration follow up**: At least 30 days postoperatively	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Choi 2016 **Retrospective Cohort** **III**	To survey the relationship between surgical drains and infection	**No. of patients: n= 70** **Patient Characteristics:** There was no significant difference between the 2 groups **Age:** Case: 49.93 Control: 43.86 **Gende**r: Case:Male:Female: 21:21 Control:Male:Female: 13:15 **Co-morbidity**: Demographics in the form of age, sex, diagnosis, and variables including hypertension, diabetes, smoking status were recorded. There was no staistical difference (p>0.05) in terms of preoperative co-morbid conditions	**Intervention Group: n=42** Placement of surgical drain Timing of Intervention: Intraoperative Duration of intervention: Postoperatively. Drain were left for average of 2.88 days Device/agent: Surgical drain Monitoring intervention: The levels of CRP were checked on postoperative days 1, 3, and 5. The amounts of surgical drainage collected for 24 hours were checked daily at the same time. In drainage group, proximal tip culture of surgical drain was conducted when removed.	**SSI (Intervention**): 0 **SSI (Control):** 2/28 (7.14%) **p value**: p=0.157 **Conclusion**: No difference in rate of SSI in single level lumbar disc surgery when drains were used vs. when no drains were used	**Definition of SSI**: N.R. **Distinction between deep and superficial SSI**: No **Conflicts of interest**: No conflicts **Sample size calculation**: No
		Procedures: Single level lumbar disc surgery **Indications**: N.R. **Setting**: University hospital **Country**: Korea **Dates**: Apr 2011 to Mar 2012	**Control Group: n=28** No drain	**Reoperation due to SSI (Intervention):** 0 **Reoperation due to SSI (Control**): 2/28 (7.14%) **p value (reoperation):** p=0.157	
		Inclusion criteria: Single-level lumbar disc surgery **Exclusion criteria:** Multi-level surgery, fusion surgery, and/or previous lumbar surgery **Method of case identification:** N.R.	**Standard perioperative measures:** AMP: Both groups received prophylactic antibiotics (1st generation cephalosporin) intravenously for 7 to 8 days Suture removal: Between postoperative days 7 and 8	**Length of Stay (Intervention):** 8.68 **Length of Stay (Control)**: 9.87 **p value (LOS):** p>0.05 **Duration follow up**: N.R.	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Poorman 2014 **Retrospective Cohort** **III**	To investigate the effectiveness of postoperative drains following one- and two-level cervical fusions	**No. of patients: n= 81** **Patient Characteristics:** There were no differences in demographics between the two groups **Age:** Test: 46.4+/-9.5 Control: 45.1+/-10.5 **Gende**r: Test: Female 53.8% Control: Female 42.8% **Co-morbidity**: Age, sex, height, weight, BMI, ASA were recorded and compared. There was no statistical significant difference between groups for the above variables	**Intervention Group: n=39** Closed-suction wound drainage placed in the prevertebral space (subfascial) Timing of Intervention: Intraoperative Duration of intervention: Postoperatively Device/agent: Closed-suction drain tube. #7 Jackson-Pratt was used in all drain cases, except for one patient who received a Penrose drain Monitoring intervention: N.R.	**SSI (Intervention**): 0 **SSI (Control):** 1 (2.4%) **p value**: p=0.33 **Conclusion**: There is no difference in the incidence of wound complications (including SSI) when wound drains were used vs. when they weren't used in cervical spine fusion surgery (1 to 2 levels)	**Definition of SSI**: N.R. **Distinction between deep and superficial SSI**: No **Conflicts of interest**: No conflicts **Sample size calculation**: No
		Procedures: One and two level anterior cervical spine fusions using Smith-Robinson approach from the right side. **Indications**: Elective one or two level anterior cervical spine fusion for radiculopathy and/or myelopathy **Setting**: N.R. **Country**: USA **Dates**: 2010 to 2013	**Control Group: n=42** No drain tube	**Reoperation due to SSI (Intervention):** 0 **Reoperation due to SSI (Control**): 0 **p value (reoperation):** N.A.	
		Inclusion criteria: Age over 18 years, elective one or two level anterior cervical spine fusion for radiculopathy and/or myelopathy **Exclusion criteria:** Operations for tumour or trauma indications, full corpectomies, revision procedures **Method of case identification:** Consecutive	**Standard perioperative measures:** N.R.	**Length of Stay (Intervention):** 38.9+/- 16.4 hours **Length of Stay (Control)**: 31.7+/010.5 hours **p value (LOS):** p=0.021 **Duration follow up**: N.R.	

Evidence Table for Q4b. Does concomitant administration of AMP in the presence of a wound drain reduce the rate of SSI in spine surgery?

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Takemoto 2015 **RCT** **I**	To compare infection rates between patients who were treated with antibiotics for 24h after spinal surgery and those who received antibiotics for the duration that the drain was in place	**No. of patients: n= 314** **Patient Characteristics:** With the exception of the ASA classification, which differed between the two groups, demographic factors including medical comorbidities, surgical approach, use of implants and bone graft, duration of surgery, number of spinal levels exposed, blood loss, or blood transfusions were similar between the two groups **Age:** Test: 58.1 (19-88) Control: 57.4 (18-86) **Gende**r: Test: M: 64 (44%), F: 80 (56%) Control: M: 78 (46%), F: 92 (54%) **Co-morbidity**: Examined: ethnicity, BMI, ETOH use, malnourishment, ASA classification. Only ASA classification showed a statistically significant p value of 0.04 between groups. ASA I - 2 (1%) in drain group, 14 (8%) in 24hour ABx group. ASA II - 90 (63%) in drain group, 96 (57%) in 24hour ABx group. ASA III - 50 (35%) in drain group, 56 (33%) in 24hour ABx group. ASA IV - 2 (1%) in drain group, 4 (2%) in 24hour ABx group. No p value given for each individual ASA grouping.	**Intervention Group: n=170** Antibiotics for 24h even if drain tube is in Timing of Intervention: Postoperative Duration of intervention: 24 hours postoperatively Device/agent: Most patients receive cefazolin. Patients with an allergy to that drug, preoperative nasal culture results positive for methicillin-resistant Staphylococcus aureus (MRSA), or a recent history of surgery with perioperative antibiotics were considered for treatment with clindamycin or vancomycin Monitoring intervention: N.R.	**SSI (Intervention**): 21 (12.4%) Deep n=7 Superficial n=14 **SSI (Control):** 19 (13.2%) Deep n=8 Superficial n=11 **p value**: p=0.48 **Conclusion**: No difference in SSI rates when antis are used for 24h vs. for the entire duration of the drain	**Definition of SSI**: CDC **Distinction between deep and superficial SSI**: Yes **Conflicts of interest**: No conflicts **Sample size calculation**: Yes
		Procedures: Multilevel thoracolumbar spine arthrodeses for deformity and degenerative conditions **Indications**: Deformity and degenerative spine conditions **Setting**: N.R. **Country**: USA **Dates**: September 2008 to February 2011	**Control Group: n=144** Antibiotics for entire duration whilst drain is in	**Reoperation due to SSI (Intervention):** 8/144 = 5.6% **Reoperation due to SSI (Control**): 7/170 = 4.1% **p value (reoperation):** p=0.6	
		Inclusion criteria: Degenerative or idiopathic spine deformity or degenerative condition that was to be treated with thoracic and/or lumbar surgery that a drain was likely to be used e.g. multilevel lami or arthrodesis	**Standard perioperative measures:** Surgeon: All operations performed by fellowship-trained orthopaedic spine surgeon	**Length of Stay (Intervention):** 5.9 (2-36) **Length of Stay (Control)**: 5.9 (2-36)	

		Exclusion criteria: - Age less than 18 - concurrent infection - cefazolin. clindamycin or vancomycin allergy - Spine trauma **Method of case identification:** Trial randomization	Dressing: All dressings were changed daily starting on postoperative Day 3 or on the day of discharge if that was sooner than 3 days postoperatively Drains: Subfascial drain tube, removed when output was <30mL in 8h	**p value (LOS):** p=0.9 **Duration follow up**: Minimum 1 year	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Kamath 2016 **Retrospective Cohort** **III**	To compare the efficacy of two antimicrobial prophylaxis (AMP) protocols with cephazolin in preventing SSI in adolescent idiopathic scoliosis (AIS).	**No. of patients: n= 226** **Patient Characteristics:** No significant differences were observed between the two groups with respect to mean age, sex, BMI, smoking, pre-operative hemoglobin, nutritional status (total protein and albumin), scoliosis curve type, mean number of levels fused per patient, intra-operative transfusion, post-operative transfusion and duration of drain left in situ. A significant difference was observed between the groups in terms of pre-operative globulin levels, type of instrumentation system, mean number of anchor points per patient, intra-operative and post-operative blood loss between the groups. **Age:** Test: Mean 15.11 (SD 2.72) Control: 15.03 (SD 2.64) **Gende**r: Test: F/M ratio: 60/11 Control F/M ratio: 132/23 **Co-morbidity**: "For pre-existing medical problems, 14 patients had allergic rhinitis and or asthma, 2 had atopy, 3 had G6PD deficiency, 3 patients had thalassemia trait and 2 with thalassemia minor, 5 patients had cardiac valve anomalies, 2 patients were obese and 1 had recovered from leukemia. No patients had anemia or any active focus of infection. No patients had diabetes or abnormal blood glucose prior to surgery." Not tabulated, nil discussion re: numbers within test/control group	**Intervention Group: n=71** Postoperative IV antibiotics (Cephazolin every 8hr) till drain removal Timing of Intervention: Postoperative Duration of intervention: Postoperatively until drain removal Device/agent: IV cefazolin Monitoring intervention: NR	**SSI (Intervention**): 1 (1.41%) 1 deep **SSI (Control):** 3 (1.94%) 1 superficial 2 deep **p value**: p=1.0 **Conclusion**: No difference in postop SSI when only 2 doses of antis was given postop when drain was in situ compared till postop antis till drain removal	**Definition of SSI**: - Deep: subfascial infection - Superficial: clinical signs of infection involving skin, subcutaneous tissue or muscle located above fascial layer accompanied by purulent drainage above fascia and positive wound culture **Distinction between deep and superficial SSI**: Yes **Conflicts of interest**: No conflicts **Sample size calculation**: N.R.
		Procedures: - All pedicle screw construct - pedicle screws and hook construct - all hooks construct	**Control Group: n=155** Postoperative two doses of IV antibiotics	**Reoperation due to SSI (Intervention):** 1/71	

		- pedicle screws, hooks and sublaminar wire construct - pedicle screw and sublaminar wire construct **Indications**: Patients with adolescent idiopathic scoliosis undergoing surgery **Setting**: N.R. **Country**: Hong Kong, China **Dates**: 1993 - 2011		**Reoperation due to SSI (Control)**: 2/155 **p value (reoperation):** N.R.	
		Inclusion criteria: Patients with adolescent idiopathic scoliosis undergoing surgery **Exclusion criteria:** - Age less than 18 - Concurrent infection - Cefazolin. clindamycin or vancomycin allergy - Spine trauma **Method of case identification:** Consecutive	**Standard perioperative measures:** AMP: IV Cephazolin was given 30 min before skin incision and an additional dose administered intra-operatively every 4 hr Perioperative assessment: Patients were admitted the day prior to surgery and were screened for any active infective focus. In the presence of an active infection, surgery was postponed until the infection was eradicated. Skin Prep: Skin preparation was standardized with providone-iodine scrub Ultraclean air: Surgeries were performed in laminar airflow theatre Wound irrigation: The surgical sites were irrigated with normal saline after completion of surgical dissection, insertion of all anchors, after rod insertion and prior to wound closure Closure: Standardized closure was performed with watertight closure of fascia and subcutaneous with continuous vicryl sutures, and buried subcuticular monocryl sutures Drain: Single suction drain was routinely placed in the spinal wound and removed when the collection was <50ml over a 24-h period	**Length of Stay (Intervention):** N.R. **Length of Stay (Control)**: N.R. **p value (LOS):** N.A. **Duration follow up**: >18 months (average 43 months)	

Domain: 5. Nutrition
Q5a. Does postoperative oral nutritional supplementation reduce the risk of SSI in spine surgery?
Q5b. Does early postoperative parenteral nutrition reduce the risk of SSI in spine surgery?

Evidence Table for Q5b. Does early postoperative parenteral nutrition reduce the risk of SSI in spine surgery?

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Hu 1998 **RCT** **II**	To determine whether use of total parenteral nutrition (TPN) in patients undergoing staged spinal reconstruction procedures could affect their nutritional parameters or decrease their complication rates	**No. of patients: n= 35** **Patient Characteristics:** N.R. **Age:** Test: 54 (range 23-75) Control: 47 (range 20-73) **Gende**r: N.R. **Co-morbidity**: Does not state, however does say excluded if poorly controlled DM, or other "medical contraindications to this protocol"	**Intervention Group: n=20** Postoperative TPN began day 1 at 40ml/hr and increased until calculated nutritional needs were met. Timing of Intervention: Postoperative Duration of intervention: Weaning of TPN begin after able to take at least 50% of calculated need orally Device/agent: TPN + subclavian Hone Catheter for administration of TPN Monitoring intervention: N.R	**SSI (Intervention**): 3 (18.75%) **SSI (Control):** 1 (5.26%) **p value**: Not significant, no value reported **Conclusion**: There is no significant difference in SSI for patients who had postop TPN versus no TPN	**Definition of SSI**: Any patient who required surgical debridement of a draining wound and intravenous antibiotics **Distinction between deep and superficial SSI**: No **Conflicts of interest**: N.R. **Sample size calculation**: N.R.
		Procedures: N.R. **Indications**: - Kyphosis - Scoliosis - Spinal stenosis - Pseudoarthrosis - Spondylolisthesis **Setting**: N.R. **Country**: USA **Dates**: May 1994 to June 1997	**Control Group: n=20** No postoperative TPN. Standard intravenous fluids given	**Reoperation due to SSI (Intervention):** n=3 (/16) = 18.75% **Reoperation due to SSI (Control**): n=1 (/19) = 5.3% **p value (reoperation):** States not statistically significant, nil value given	
		Inclusion criteria: Patients scheduled for two-stage anterior and posterior spinal surgery, scheduled 5-7 days apart **Exclusion criteria:** Poorly controlled diabetes or had other medical contraindications to this protocol **Method of case identification:** N.R.	**Standard perioperative measures:** Nutrition: Oral feeds were commenced when had bowel sound and began to pass flatus.	**Length of Stay (Intervention):** N.R. **Length of Stay (Control)**: N.R. **p value (LOS):** N.A. **Duration follow up**: N.R.	

Domain: 6. Clinical Care Pathways
Q6a. Does implementation of infection-specific care pathways reduce the rate of SSI in spine surgery?
Q6b. Do enhanced-recovery after surgery (ERAS) pathways reduce the rate of SSI in spine surgery?

Evidence Table for Q6a. Does implementation of infection-specific care pathways reduce the rate of SSI in spine surgery?

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Featherall 2016 **Prospective Cohort** **III**	To evaluate whether implementation of an infection prevention bundle would be associated with a reduction in SSIs and disease-specific costs	**No. of patients: n= 1770** **Patient Characteristics:** There are no significant difference in demographics, co-morbidity, smoking status, admission type and diagnostic indication between the two groups **Age** Test: 58 +/- 15 Control: 58+/- 14 **Gende**r: Test: M: 58% Control: M: 56% **Co-morbidity**: N.R.	**Intervention Group: n=799** Implementation of a 9 components infection prevention bundle: (1) Screening for Staphylococcus aureus nasal colonization and decolonization with mupirocin (2) Self-preparation bath with chlorhexidine gluconate (3) Self-preparation with chlorhexidine gluconate wipes (4) Storage optimization of operating room supplies (5) Preoperative antibiotic administration algorithm (6) Staff training on betadine scrub and paint (7) Intrawound vancomycin in instrumented cases (8) Postoperative early patient mobilization (9) Wound checks at 2 and 6 weeks postoperatively. Timing of Intervention: Preoperative, intraoperative and postoperative Duration of intervention: Preoperatively, intraoperatively and postoperatively Monitoring intervention: N.R.	**SSI (Intervention**): 16 (2.00%) **SSI (Control):** 40 (4.12%) **p value**: p=0.01 **Conclusion**: Implementation of infection control bundle is associated with 50% reduction in SSI and $866 per capita reduction in the surgical episode of care	**Definition of SSI**: National healthcare safety network **Distinction between deep and superficial SSI**: No **Conflicts of interest**: No conflicts **Sample size calculation**: N.R.
		Procedures: - Fusion - Revision - Discectomy = Vertebral augmentatin - Tumour resection - Other **Indications**: - Degenerative - Other e.g. pathologic fractures, metabolic, autoimmune and inherited bone disease - Malignancy - Deformity **Setting**: University hospital **Country**: USA	**Control Group: n=971** Pre-bundle postop care	**Reoperation due to SSI (Intervention):** N.R. **Reoperation due to SSI (Control**): N.R. **p value (reoperation):** N.A.	

		Dates: March 2012 to December 2013			
		Inclusion criteria: Patients undergoing discectomy, decompression, augmentation or fusion of the spine **Exclusion criteria:** N.R. **Method of case identification:** N.R.	**Standard perioperative measures:** N.R.	**Length of Stay (Intervention):** 3 IQR(1-5) **Length of Stay (Control)**: 3 IQR(1-5) **p value (LOS):** p = 0.72	
				Duration follow up: Wound check at 2 and 6 weeks post-operatively. Average follow up: 365 days	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Gould 2016 **Retrospective Cohort** **III**	To design a combined pre-, peri-, and postoperative bundle (PPPB) that would lead to sustained reductions in SF-SSI rates.	**No. of patients: n= 224** **Patient Characteristics:** N.R. **Age:** N.R. **Gende**r: N.R. **Co-morbidity**: N.R.	**Intervention Group: n=126** Implementation of a pre, peri- and postoperative bundle: Preoperative - Soap & water bath and hair washing, followed by 2% CHG bath cloth application (neck to toes) the night before & morning of surgery - Dermatology assessment tool and consultation if necessary Perioperative - Use of 2% CHG/70% isopropyl alcohol for skin antisepsis in OR - Antimicrobial silver wound contact dressing (Silverlon) application after closure of incision in the OR Postoperative in hospital - Designated nursing unit for expertise and consistency of care - Postoperative nursing standard of care - “Back Home” teaching tool for nurses. Teach back is required. Postoperative at home (postdischarge) - Back Home kit - Written discharge instructions: · Hand hygiene significance for patient and caregivers · Surgical dressing changed if loose or soiled; maintained for 1 week · Keeping the incision area clean includes the following: · Personal hygiene: daily chlorhexidine bath	**SSI (Intervention**): 3 (2.4%) **SSI (Control):** 8 (8.2%) **p value**: p=0.695 **Conclusion**: Infection prevention bundle leads to sustained but non-significant reduction in SSI	**Definition of SSI**: N.R. **Distinction between deep and superficial SSI**: No **Conflicts of interest**: No conflicts **Sample size calculation**: N.R.

			· Diaper changes every 2 hours; meticulous cleanliness of the lower back · Keep hair up and away from the incision · Clean linens and clothing, keeping pets off areas where the patient rests · Avoid swimming until cleared by physician during follow-up · Signs and symptoms of infection, doctor's phone number · Follow-up appointment 7 days after leaving the hospital Timing of Intervention: Preoperative, intraoperative and postoperative Duration of intervention: Preoperatively, intraoperatively and postoperatively Monitoring intervention: N.R.		
		Procedures: Spinal fusion with Ti pedicle screws and double rodding (one Ti and one CoCr), use of synthetic bone graft matrix **Indications**: Scoliosis **Setting**: University hospital **Country**: USA **Dates**: January 2008 to February 2015	**Control Group: n=98** Pre-bundle care	**Reoperation due to SSI (Intervention):** N.R. **Reoperation due to SSI (Control**): N.R. **p value (reoperation):** N.A.	
		Inclusion criteria: All paediatric patients undergoing spinal fusion surgery **Exclusion criteria:** N.R. **Method of case identification:** N.R.	**Standard perioperative measures:** AMP: Perioperative antibiotic were used Skin Prep: Chlorhexidine gluconate skin antisepsis	**Length of Stay (Intervention):** N.R. **Length of Stay (Control)**: N.R. **p value (LOS):** N.A. **Duration follow up**: N.R.	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Meyer 2010 **Retrospective Cohort** **III**	To design a combined pre-, peri-, and postoperative bundle (PPPB) that would lead to sustained reductions in SF-SSI rates.	**No. of patients: n= 1935** **Patient Characteristics:** N.R. **Age:** N.R. **Gende**r: N.R.	**Intervention Group: n=887** Implementation of an infection prevention bundle: 1) Planning of the operation – Elective operation + preoperative in-hospital stay was limited to a maximum of 2 days 2) preop hair removal – using a clipper prior to disinfection	**SSI (Intervention**): 0 (0%) **SSI (Control):** 6 (0.57%) **p value**: p=0.025 **Conclusion**: Perioperative	**Definition of SSI**: N.R. Paper looked only at deep SSI No formal definition of "Deep" SSI **Distinction between deep and superficial SSI**: N.A.

		Co-morbidity: N.R.	3) antibiotic prophylaxis - Cefazoline is recommended for spinal surgery., a second dose should be administered at 3 – 4 h after the operation. Antibiotic prophylaxis should be administered at least 30 min prior to and no more than 2 h before incision 4) incision drapes – strong adhesive drapes containing iodophor 5) surgical gloves – Double gloving + immediate change of a perforated glove 6) surgical technique - avoidance of excessive blood loss + reduce length of surgery. Prior to primary wound closure, wound flushing with sterile saline fluid 7) Anaesthesiology – Avoid hypothermia, hyperglycemia and ensure optimal oxygenation and hemostasis. Intraoperative muscle relaxation reduce stress due to retraction 8) wound closure/drains - drains should not be used routinely and for as short a period as possible 9) wound dressings -incision site is covered with a dressing that is both sterile and absorptive. Dressing should not be changed within the first 48h unless bleeding, contamination or signs of infection Timing of Intervention: Preoperative, intraoperative and postoperative Duration of intervention: Preoperatively, intraoperatively and postoperatively Monitoring intervention: N.R.	care in spinal surgery for the prevention of deep wound infections was found to effectively reduce infection rates.	Paper only looked at deep SSI **Conflicts of interest**: No conflicts **Sample size calculation**: N.R.
		Procedures: - Non instrumented thoracic and lumbar surgery - Non-instrumented cervical spine surgery - Instrumented thoracic and lumbar surgery - Instrumented cervical spine surgery **Indications**: N.R. **Setting**: N.R. **Country**: Germany **Dates**: January 2006 to December2007	**Control Group: n=1048** Pre-infection prevention bundle	**Reoperation due to SSI (Intervention):** N.R. **Reoperation due to SSI (Control**): N.R. **p value (reoperation):** N.A.	
		Inclusion criteria: Any spinal surgery **Exclusion criteria:** N.R.	**Standard perioperative measures:** N.R.	**Length of Stay (Intervention):** N.R. **Length of Stay (Control)**: N.R. **p value (LOS):** N.A.	

		Method of case identification: N.R.		**Duration follow up**: N.R.	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Argarwal 2017 **Retrospective Cohort** **III**	To investigate the effects of the development and implementation of an infection prevention protocol that was augmented by increased physician awareness of spinal fusion surgical site infection (SSI) rates and resultant cost savings	**No. of patients: n= 10225** **Patient Characteristics:** N.R. **Age:** N.R. **Gende**r: N.R. **Co-morbidity**: N.R.	**Intervention Group: n=829** Implementation of an infection prevention bundle and physician awareness program: Preoperative 1) 4% CHG preoperative bathing for 5 days 2) Nasal screening for Staphylococcus aureus preoperatively with administration of 2% mupirocin ointment for nasal decolonization for 5 days for positive tests 3) CHG-alcohol as the standard preoperative preparation unless contraindicated. Postoperative 1) Requiring sterile technique for surgical dressing changes, 2) Requiring dressings to be changed daily for 7 days after spine surgery 3) Standardization of dressing changes. Timing of Intervention: Preoperative, intraoperative and postoperative Duration of intervention: Preoperatively, intraoperatively and postoperatively Monitoring intervention: N.R.	**SSI (Intervention**): 2.1% **SSI (Control):** 3.8% **p value**: p=0.03 **Conclusion**: Spine surgery infection control measures combined with physician awareness successfully decreased postoperative SSI, thereby also resulting in significant cost savings	**Definition of SSI**: N.R. **Distinction between deep and superficial SSI**: No **Conflicts of interest**: No conflicts **Sample size calculation**: No
		Procedures: Spinal fusion surgery **Indications**: N.R. **Setting**: Academic hospital **Country**: USA **Dates**: Control: Jan 2007 to Feb 2011 Test: May 2015 to Jul 2016	**Control Group: n=6643** Pre-infection prevention bundle	**Reoperation due to SSI (Intervention):** N.R. **Reoperation due to SSI (Control**): N.R. **p value (reoperation):** N.A.	
		Inclusion criteria: Patients undergoing spinal fusion surgery	**Standard perioperative measures:** N.R.	**Length of Stay (Intervention):** N.R. **Length of Stay (Control)**: N.R.	

		Exclusion criteria: N.R. **Method of case identification:** N.R.		**p value (LOS):** N.A. **Duration follow up**: N.R.	

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Glotzbecker 2018 **Retrospective Cohort** **III**	To measure SSI outcomes before and after implementation of a multidisciplinary clinical pathway protocol for high-risk spinal surgery	**No. of patients: n= 24** **Patient Characteristics:** The pre- and post-implementation groups were not different with respect to patient age, sex, and diagnosis. The median number of levels fused was the same across cohorts however, the postpathway cohort had a higher pro-portion of subjects with iliac screw instrumentation (**Age:** Test: 15+/-4.61 Control: 14.9+/-3.33 **Gende**r: Test:Male 43% Control:Male 55% **Co-morbidity**: No difference in rates of neuromuscular, syndromic, congenital or idiopathic conditions between groups	**Intervention Group: n=115** Implementation of a multidisciplinary clinical pathway to reduce deep surgical site infection: Components based on nationally published Best Practice Guidelines 1) Preop chlorhexidine wash at home 2) Preop urine cultures 3) Preop patient education sheet 4) Preop nutritional assessment 5) Preop intravenous cephazolin and coverage for gram-negative bacilli 6) Adherence and monitoring of antibiotic regimens 7) Limiting operating room traffic 8) Use of intraoperative irrigation 9) Vancomycin added to bone graft 10) Use of impervious dressings 11) Minimizing postoperative dressing changes Components based on experienced multidiscipline consensus 1) Preoperative assessment and postoperative review at a multidisciplinary conference 2) Use of preoperative bowel preparation 3) Methicillin-resistant/sensitive Staphylococcus aureus (MRSA/MSSA) screening and decolonization 4) Time limitations on anesthetic and surgical times, time limitations on when implants are opened 5) Use of dilute betadine irrigation prior to closure 6) Limiting blood loss by using multimodal patient blood management techniques 7) Patient body temperature control measures 8) Postoperative care (pulmonary, dressing care, etc). Timing of Intervention: Preoperative, intraoperative and postoperative Duration of intervention: Preoperatively, intraoperatively and postoperatively	**SSI (Intervention**): Overall: 7 (6.1%) Deep: 1 (0.9%) Superficial: 6 (5.2%) **SSI (Control):** Overall: 12 (9.1%) Deep: 11 (8.3%) Superficial: 1 (0.8%) **p value**: p=0.005 **Conclusion**: Implementation of a multidisciplinary pathway aimed to reduce infection in patients at high risk for SSI after spinal fusion led to a significant reduction of deep SSI rate but not overall SSI rate	**Definition of SSI**: CDC **Distinction between deep and superficial SSI**: Yes **Conflicts of interest**: No conflicts **Sample size calculation**: No

			Monitoring intervention: N.R.		
		Procedures: Posterior spinal fusion with median of 15 levels fused per group **Indications**: Neuromuscular, syndromic, congenital or idiopathic conditions requiring posterior spinal fusion. Age, gender were also not significantly different **Setting**: N.R. **Country**: USA **Dates**: Pre pathway: 2008 to 2012 Post pathway: 2013 to 2016	**Control Group: n=132** Pre-implementation of multidisciplinary clinical pathway	**Reoperation due to SSI (Intervention):** 8 (7.0%) **Reoperation due to SSI (Control**): 17 (12.9%). **p value (reoperation):** p=0.13	
		Inclusion criteria: Included: paediatric patients with high risk conditions i.e. neuromuscular or syndromic diagnosis based on medical comorbidities were included - Long constructs requiring instrumentation to pelvis - Prolonged operation >8h - Prolonged ICU stay - Staged operations - Combined anterior/posterior procedures - Fusion after prolonged traction - Myelodydplasia - Cerebral palsy - Pulmonary or cardiac insufficiency - Ventilator dependence - Severe seizure disorder - Myopathy or muscular dystrophy - Nutritional insufficiency - Lymphocyte count <1500/mm^3 - Albumin <3.5g/dL - Prior infection - Incontinence - History of decubitus ulcer - Obesity (BMI >30) **Exclusion criteria:** Patients with adolescent idiopathic scoliosis, growth-friendly operations, trauma, or current infections **Method of case identification:** Consecutive	**Standard perioperative measures:** N.R.	**Length of Stay (Intervention):** Median 9 days **Length of Stay (Control)**: Median 9 days **p value (LOS):** p=0.53	
				Duration follow up: Pre-pathway implementation: Median 5.7 years Post-pathway implementation: Median 2.6 years	

Evidence Table for Q6b. Do enhanced-recovery after surgery (ERAS) pathways reduce the rate of SSI in spine surgery?

Author/Year	Study Aim	Population and Setting	Intervention and Control Group	Results	Comments
Debono 2019 **Retrospective Cohort** **III**	To report on initial experience in applying ERAS program to several degenerative spinal fusino procedures over two 2 year periods	**No. of patients: n= 3483** **Patient Characteristics:** There was no significant difference between groups among the ALIF patients in terms of age, sex, BMI, ASA classification, tobacco use, and uni- or multilevel procedures. Regarding the ACDF patients, the only significant difference between the period groups concerned multilevel procedures, which were more frequent in the post-ERAS period Among patients with posterior fusion, there were significantly fewer smokers and more multilevel procedures in the post-ERAS period. **Age:** Test ALIF (n=202) 46.3 ± 10.7, ACDF (n=612) 48.7 ± 8.7, PLF (n=1106) 56.1 ± 10.2 Control ALIF (n=159) 44.5 ± 8.6, ACDF (n=749) 47.6 ± 9.9, PLF (n=665) 53.8 ± 14.3 **Gende**r: % of Female subjects Test ALIF : 99 (49.0%) ACDF :300 (49.0%) PLF :564 (51.0%) Control ALIF :90 (56.6%) ACDF :342 (45.6%) PLF : 326 (49.8%) **Co-morbidity**: BMI, ASA I, tobacco ALIF: None of these were statistically significant ACDF: None of these were statistically significant PLF: Smoking significantly lower in test group (454 (41.0%) vs. 321 (49.0%) p = 0.001).	**Intervention Group: n=202** Implementation of Enhanced Recovery After Surgery (ERAS) protocol: - 24h unit dedicated to support ERAS care - Patient briefing session preop with surgeon, anaesthetist, physiotherapist, ERAS nurse - Nurse on call to maintain permanent telephone link with patient when at home - Limited premedication pre-op - Fast 6h prior to surgery for solids - Clear fluids till 2h pre-op - Minimally invasive techniques whenever possible - Drastic reduction in wound drain use. Use of braces, lumbar belts, cervical collars discouraged - Early advice received from rehabilitation team - Checklist approach postoperatively on ward - Opioid-sparing multimodal analgesia favouring tramadol and NSAIDs - ERAS nurse available by phone or mobile application 24h a day on discharge - Mobile app triggers alarms if patient does not check app, has a VAS score >6, a fever >38deg, voiding difficulty, new neurological deficit, blood stain on dressing. Alarm triggers a call from the ERAS nurse Timing of Intervention: Preoperative, intraoperative and postoperative Duration of intervention: Preoperatively, intraoperatively and postoperatively Monitoring intervention: N.R.	**SSI (Intervention**): Overall SSI: 38/1920 (1.98%) ALIF: 7/202 (3.5%) ACDF:3/612 (0.5%) Lumbar fusion: 28/1106 (2.5%) **SSI (Control):** Overall: 34 of 1563 ALIF: 5/159 (3.1%) ACDF: 4/749 (0.5%) Lumbar fusion: 25/655 (3.8%) **p value**: N.R. **Conclusion**: No specific mention on SSI in discussion	**Definition of SSI**: N.R. **Distinction between deep and superficial SSI**: No **Conflicts of interest**: No conflicts **Sample size calculation**: No
		Procedures: ALIF, ACDF, any posterior or postrolateral fusion (TLIF, PLIF)	**Control Group: n=159** Pre-ERAS standard management	**Reoperation due to SSI (Intervention):** Re-operation	

		Indications: Degenerative spine disease only **Setting**: University hospital **Country**: Europe **Dates**: 2012 - 2017		rates reported but not possible to tell reason for re-operation **Reoperation due to SSI (Control)**: Re-operation rates reported but not possible to tell reason for re-operation **p value (reoperation):** N.A.	
		Inclusion criteria: Degenerative cases only ALIF, ACDF, any posterior or postrolateral fusion **Exclusion criteria:** Scoliosis and large deformities deemed not suitable for ERAS **Method of case identification:** N.R.	**Standard perioperative measures:** N.R.	**Length of Stay (Intervention):** ALIF: 3.33 ± 0.8 ACDF: 1.3 ± 0.7 PLF: 4.8 ± 2.3 **Length of Stay (Control)**: ALIF: 6.06 ± 1.1 ACDF: 3.08 ± 0.9 PLF: 6.7 ± 4.8 **p value (LOS):** p<0.001	
				Duration follow up: >90days Mobile app checklist within first 48 hours. Can be used up to the first 15 days. Clinic at 6 weeks. Phone survey at 3 months. Mobile app also used in ERAS group only for online survey - end of e-health follow up period. Online clinical evaluation of Pain & QoL scores.	

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Sivaganesan 2018 **Retrospective Cohort** **III**	To compare the 90 day outcomes and complications before and after implementation of a perioperative elective spine surgery protocol	**No. of patients: n= 1747** **Patient Characteristics:** The postprotocol cohort had a significantly greater proportion of patients with symptom duration for >12 months before surgery, a higher rate of chronic obstructive pulmonary disease, lower mean estimated blood loss and lower baseline Oswestry Disability Index. No other significant differences in baseline demographics, comorbidities, or surgical characteristics were observed. **Age:** Test: 56.7 ± 13.8 Control: 57.7 ± 13	**Intervention Group: n=151** Implementation of multidimensional, evidence-based perioperative protocol - Early & frequent ambulation - No bracing for lumbar fusion - No collar for ACDF - Drain removal when output <100ml/shift or postop day 2, whichever is earlier (exception if large est. blood loss, coagulopathy, or infection) - Multimodal postop analgesia with acetaminophen, gabapentin, celecoxib PRN, long-acting opioids, antispasmodics as needed	**SSI (Intervention**): 3 (1.9%) **SSI (Control):** 52 (3.3%) **p value**: p=0.14 **Conclusion**: No difference in rate of SSI comparing pre and post ERAS protocols	**Definition of SSI**: N.R. **Distinction between deep and superficial SSI**: No **Conflicts of interest**: No conflicts **Sample size calculation**: N.R.

		Gender: Test: Male: 74 (49%) Control: Male: 815 (51.1%) **Co-morbidity**: ASA, BMI, AMI, HTN, DM, CAD, CHF, COPD, AF, arthritis. Higher rate of COPD in post-protocol cohort p= 0.024 Others not statistically significant	- Postoperative regimen of antibiotics for patients with comorbidities or undergoing complex surgery - Mobilization on postop day 1 Timing of Intervention: Preoperative, intraoperative and postoperative Duration of intervention: Preoperatively, intraoperatively and postoperatively Monitoring intervention: N.R.		
		Procedures: - ACDF: 21.8% (33) in test, 21.9% (350) in control - Microdiscectomy: 8.6%(13) in test, 10.9% (175) in control - Laminectomy: 19.8% (30)in test, 20.1% (321) in control - Laminectomy + Fusion: 49.7% (75) in test, 46.99% (750) in control **Indications**: - Had stenosis, disc disease, spondylolisthesis, adjacent segment disease or pseudarthrosis -- Underwent cervical or lumbar degenerative pathology **Setting**: University hospital **Country**: USA **Dates**: Pre-protocol: October 2010 to June 2015 Post-protocol: July 1, 2015 to April 30, 2016	**Control Group: n=1596** Pre-implementation of multidimensional, evidence-based perioperative protocol	**Reoperation due to SSI (Intervention):** N.R. **Reoperation due to SSI (Control**): N.R. **p value (reoperation):** N.A.	
		Inclusion criteria: - Older than 18 years old - Had stenosis, disc disease, sppondylolisthesis, adjacent segment disease or pseudoarthrosis - Failed 3 months of non-operative management - Underwent cervical or lumbar degnerative pathology - Number of levels operated on <=4 - Had completed postoperative 90 day follow up **Exclusion criteria:** N.R. **Method of case identification:** Consecutive	**Standard perioperative measures:** N.R.	**Length of Stay (Intervention):** 1.8 +/- 1.6 **Length of Stay (Control)**: 1.9 +/- 1.7 **p value (LOS):** p=0.124 **Duration follow up**: 3 months	

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Rao 2017 **Retrospective Cohort** **III**	To demonstrate that using pllan of care-educating families preoperatively and standardizing some aspects of care - wound decrease time to mobility and time to discharge while maintaining pain control and patient satisfaction	**No. of patients: n= 190** **Patient Characteristics:** N.R. **Age:** 1st Protocol: 14.9 (11-20) 2nd Protocol: 13.5 (11-20) Pre-protocol 15.0 (11-21) **Gende**r: N.R. **Co-morbidity**: N.R.	**Intervention Group: n=139** Implementation of multidisciplinary, evidence-driven plan of care There are two test groups (and one control group) in this study There are many postop instructions, with multimodal analgesia, dressing instructions, early oral nutrition, early IDC removal, early mobilisation as cornerstones - Early PCA withdrawal once tolerating oral diet, opioid-sparing analgesia - Changing of dressings only if dressing saturated - Removal of hemovac drain postop Day 2 - Dressing change postop Day 2 - Diet: clear liquids Day 1, General diet from Day 2 onwards - Commence bowel regime postop Day 1, remove foley catheter postop Day2 if able to stand - Cease cephazolin when hemovac drain removed only - Sit in chair postop Day 1 - Sit in chair and ambulate postop Day 2 Timing of Intervention: Preoperative, intraoperative and postoperative Duration of intervention: Preoperatively, intraoperatively and postoperatively Monitoring intervention: N.R.	**SSI (Intervention**): First protocol: n=0 Second protocol: n=1 (3%) **SSI (Control):** n=0 (0%) **p value:** N.R. **Conclusion**: No statistical calculation. No difference in rate of SSI postoperatively	**Definition of SSI**: N.R. **Distinction between deep and superficial SSI**: Yes **Conflicts of interest**: No conflicts **Sample size calculation**: N.R.
		Procedures: Posterior spinal fusion for scoliosis **Indications**: Adolescent idiopathic scoliosis **Setting**: University hospital **Country**: USA **Dates**: Dec 2008 to Dec 2014	**Control Group: n=51** Pre-implementation of multidisciplinary, evidence-driven plan of care	**Reoperation due to SSI (Intervention):** 0 **Reoperation due to SSI (Control**): 0 **p value (reoperation):** N.A.	
		Inclusion criteria: - Age 10 - 25 years old - underwent posterior spinal fusion for adolescent idiopathic scoliosis **Exclusion criteria:** - neuromuscular scoliosis	**Standard perioperative measures:** N.R.	**Length of Stay (Intervention):** 1st Protocol: 98.4± 27.8 h 2nd Protocol: 84.3± 27.2 h **Length of Stay (Control)**: N.R. **p value (LOS):** N.A.	

		- inability to participate in survery even with parent's assistance **Method of case identification:** Hospital records		**Duration follow up**: >12 months	

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Fletcher 2017 **Retrospective Cohort** **III**	To evaluate the impact of a novel postoperative pathway on length of stay and complications in posterior spinal fusion for adolescent idiopathic scoliosis	**No. of patients: n= 35** **Patient Characteristics:** There was no difference in age or sex between groups. Radiographic analysis of preoperative curve magnitudes revealed no difference in proximal thoracic or main thoracic Cobb magnitudes and a small difference in thoracolumbar curve magnitudes between groups. Accelerated discharge patients were treated using a lower mean pedicle screw density with fewer levels fused and had a shorter surgical time with a similar estimated blood loss **Age:** Test: 14.1± 1.6 Control: 14.9± 1.83 **Gende**r: N.R. **Co-morbidity**: ASA score Univariate regression analysis did not show an association between wound complications and ASA score	**Intervention Group: n=105** Implementation of Accelerated discharge pathway (AD group) Postop measures - Dressings not changed between 7-10 days postop - Multimodal analgesia with m PCA and IV diazepam, ketorolac Q6h PRN - Diet on POD 1 - Oral analgesia as soon as diet tolerated - Early mobilization twice daily from morning after surgery Pre and Intra-op measures - Hospital tour preop - Preop CHG bathes - Skin prep with chloraprep - Dermabond wound closure - Morphine PCA postop and IV diazepam Timing of Intervention: Preoperative, intraoperative and postoperative Duration of intervention: Preoperatively, intraoperatively and postoperatively Monitoring intervention: N.R.	**SSI (Intervention**): "Type 2" wound complications = 1/105 (1.1%) **SSI (Control):** "Type 2" wound complications = 1/45 (2.2%) **p value**: p=0.51 **Conclusion**: No difference in rate of SSI comparing pre and post ERAS protocols	**Definition of SSI**: N.R. **Distinction between deep and superficial SSI**: No **Conflicts of interest**: No conflicts **Sample size calculation**: N.R.
		Procedures: Posterior spinal fusion for scoliosis **Indications**: Adolescent idiopathic scoliosis **Setting**: N.R. **Country**: USA **Dates**: N.R.	**Control Group: n=45** Traditional discharge pathway managed on basis of treating surgeon's preferences without pathway (TD group)	**Reoperation due to SSI (Intervention):** 1.1% (1/105) **Reoperation due to SSI (Control**): 2.2% (1/45) **p value (reoperation):** p=0.51	
		Inclusion criteria: - Age 10 to 18	**Standard perioperative measures:** N.R.	**Length of Stay (Intervention):** median 2.17 d [95% CI, 2.11-2.23]	

		- Posterior spinal fusion for adolescent idiopathic scoliosis - Completed at least 6 month follow up **Exclusion criteria:** - patients treated with anterior or combined spinal fusion - congenital, syndromic, neuromuscular scoliosis - inadequate duration of follow up - intraoperative neuromonitoring changes **Method of case identification:** N.R.		**Length of Stay (Control)**: median 4.21 d [95% CI, 4.04-4.92] **p value (LOS):** P< 0.0001 **Duration follow up**: 6 months	