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# Supplemental Methods

## Identification of minimally invasive spine (MIS) surgery techniques

Because the description of MIS techniques in operative reports varies between surgeons and use is not reliably captured in procedure codes, we identified cases involving MIS approaches based on use of a minimally invasive component sets from detailed intraoperative supply logs.

## Handling of microbiology results

All positive cultures obtained within the first 90 postoperative days from tissue, fluid, or cerebrospinal fluid were reviewed. Those with unambiguous specimen source descriptions (see Supplemental Table 3, Supplemental Digital Content) attributed to the index surgical site were included. Identical species isolated multiple times from an individual patient were counted only once. If instances in which one or more cultures were reported only to the genus level (e.g. *Enterococcus*), if a separate culture of the same genus was further speciated (e.g. *Enterococcus faecalis)* in the same patient episode,the species of the former isolate was assumed to be that of the latter and not counted separately.

Because coagulase-negative Staphylococci (CoNS) and gram-positive rods have an established role as pathogens in instrumented spine surgery, but may also represent “contaminants” from normal culture sampling and handling processes, these organisms were considered pathogenic if a) isolated from more than one culture with at least one being a deep tissue culture or b) no other organisms were cultured.

Antimicrobial resistance was determined in a stepwise fashion: first, according to the results of direct susceptibility testing when available, then by probabilistic assignment according to the hospital’s antibiogram, then by published estimates of organism-specific susceptibility if not included in the institutional antibiogram. Inducible resistance phenotypes (e.g. induction/derepression of AmpC β-lactamase) were not considered in the determination of resistance because induction would not be expected to occur within a timescale relevant to short-term, prophylactic dosing.

# Supplemental Tables

## Supplemental Table 1. Enteric organism list

|  |
| --- |
| Anaerobic gram negative rods |
| Anaerobic gram positive cocci |
| Anaerobic gram positive rods |
| Bacteroides fragilis |
| Lactobacillus |
| Mixed anaerobic flora |
| Peptostreptococcus |
| Prevotella |
| Prevotella bivia |
| Anaerobic gram negative cocci |
| Escherichia coli |
| Enterobacter |
| Enterobacter asburiae |
| Enterobacter cloacae |
| Enterobacter aerogenes |
| Enterococcus |
| Enterococcus faecalis |
| Enterococcus faecium |
| Enterococcus casseliflavus |
| Enterococcus gallinarum |
| Klebsiella |
| Klebsiella pneumoniae |
| Klebsiella oxytoca |
| Morganella morganii |
| Citrobacter freundii complex |
| Gram negative rods |
| Providencia rettgeri |
| Serratia |
| Serratia marcescens |
| Lactose fermenting gram negative rods |
| Non lactose fermenting gram negative rods |
| Proteus |
| Proteus mirabilis |
| Proteus vulgaris |
| Pseudomonas aeruginosa |
| Pseudomonas |
| Anaerobic non-spore forming gram positive rods |
| Citrobacter koseri |
| Eggerthella |
| Peptoniphilus |
| Peptoniphilus harei |
| Prevotella melaninogenica |

## Supplemental Table 2. Cutaneous organism list

|  |
| --- |
| Cutibacterium acnes |
| Staphylococcus capitis |
| Staphylococcus epidermidis |
| Staphylococcus lugdunensis |
| Staphylococcus pasteuri |
| Staphylococcus saccharolyticus |
| Staphylococcus, coagulase negative |
| CoNS |
| Staphylococcus schleiferi |
| Staphylococcus simulans |
| Candida albicans |
| Trichosporon inkin |
| Candida glabrata |
| Candida tropicalis |
| Candida parapsilosis |
| Candida |
| Yeast |
| Trichosporon |
| Finegoldia |
| Micrococcus luteus |
| Staphylococcus intermedius group |
| Staphylococcus pseudintermedius |
| Staphylococcus |
| Actinomyces odontolyticus |
| Aerobic non-sporeforming gram positive rods |
| Bacillus species, not B. anthracis |
| Corynebacterium |
| Diphtheroids |
| Corynebacterium tuberculostearicum |
| Clostridium perfringens |
| Corynebacterium striatum |
| Cutibacterium |
| Corynebacterium jeikeium |
| Clostridium |
| Bacillus species |
| Gram positive rods |
| Corynebacterium amycolatum |
| Staphylococcus aureus |
| Beta hemolytic Streptococcus, Group B |
| Streptococcus milleri group |
| Viridans streptococci |
| Streptococcus milleri |
| Beta hemolytic Streptococcus, Group A |
| Granulicatella adiacens |
| Finegoldia magna |
| Beta hemolytic Streptococcus |
| Dermacoccus |
| Gram positive cocci |
| Streptococcus |

## Supplemental Table 3. Specimen source descriptions

(Including common misspellings)

|  |
| --- |
| back |
| buttock |
| c1 |
| c2 |
| c3 |
| c4 |
| c5 |
| c6 |
| c7 |
| cervial |
| cervical |
| coccyx |
| deep |
| disc |
| epidural |
| epideral |
| epidermal |
| faucet |
| facet |
| hardware |
| iliac |
| ilium |
| implant |
| inplant |
| intraspinal |
| l1 |
| l2 |
| l3 |
| l4 |
| l5 |
| lamina |
| lumbar |
| neck |
| paraspinal |
| paraspinous |
| pedicle |
| pellicle |
| perispinal |
| prevertebral |
| psoas |
| psous |
| retroperitoneal |
| s1 |
| sacral |
| sacrum |
| screw |
| spinal |
| spine |
| t1 |
| t10 |
| t11 |
| t12 |
| t2 |
| t3 |
| t4 |
| t5 |
| t6 |
| t7 |
| t8 |
| t9 |
| thoracic |
| thoracolumbar |
| thorasic |
| thorax |
| tissue |
| vertebral |

# Supplemental Figures



## Supplemental Figure 1.

In this analysis, the absolute count (rather than relative abundance) of species at each level is shown. The gradient in Figure 1 of the main text is due to an absolute increase in gram-negative infection at lower levels rather than a decrease in gram-positive infection.



## Supplemental Figure 2.

Absolute count of SSIs stratified by lowest level (rather than all levels) involved in the operation. Using inferior extent of the procedure as an indicator, the increase in gram-negative infection occurs at the thoracolumbar junction.

# References

1. *Procedure-associated Module: Surgical Site Infection (SSI) Event*. Centers for Disease Control. Available at https://www.cdc.gov/nhsn/pdfs/pscmanual/9pscssicurrent.pdf. January 2020.