Building Consensus: Development of a Best Practice Guideline (BPG) for Surgical Site Infection (SSI) Prevention in High-risk Pediatric Spine Surgery

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Background: Perioperative surgical site infection (SSI) after pediatric spine fusion is a recognized complication with rates between 0.5% and 1.6% in adolescent idiopathic scoliosis and up to 22% in "high risk" patients. Significant variation in the approach to infection prophylaxis has been well documented. The purpose of this initiative is to develop a consensus-based "Best Practice" Guideline (BPG), informed by both the available evidence in the literature and expert opinion, for high-risk pediatric patients undergoing spine fusion. For the purpose of this effort, high risk was defined as anything other than a primary fusion in a patient with idiopathic scoliosis without significant comorbidities. The ultimate goal of this initiative is to decrease the wide variability in SSI prevention strategies in this area, ultimately leading to improved patient outcomes and reduced health care costs.

Methods: An expert panel composed of 20 pediatric spine surgeons and 3 infectious disease specialists from North America, selected for their extensive experience in the field of pediatric spine surgery, was developed. Using the Delphi process and iterative rounds using a nominal group technique, participants in this panel were as follows: (1) surveyed for current practices; (2) presented with a detailed systematic review of the relevant literature; (3) given the opportunity to voice opinion collectively; and (4) asked to vote regarding preferences privately. Round 1 was conducted using an electronic survey. Initial results were compiled and discussed face-to-face. Round 2 was conducted using the Audience Response System, allowing participants to vote for (strongly support or support) or against inclusion of each intervention. Agreement $>80\%$ was considered consensus. Interventions without consensus were discussed and revised, if feasible. Repeat voting for consensus was performed.

Results: Consensus was reached to support 14 SSI prevention strategies and all participants agreed to implement the BPG in their practices. All agreed to participate in further studies assessing implementation and effectiveness of the BPG. The final consensus driven BPG for high-risk pediatric spine surgery patients includes: (1) patients should have a chlorhexidine skin wash the night before surgery; (2) patients should have preoperative urine cultures obtained; (3) patients should receive a preoperative Patient Education Sheet; (4) patients should have

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a preoperative nutritional assessment; (5) if removing hair, clipping is preferred to shaving; (6) patients should receive perioperative intravenous cefazolin; (7) patients should receive perioperative intravenous prophylaxis for gram-negative bacilli; (8) adherence to perioperative antimicrobial regimens should be monitored; (9) operating room access should be limited during scoliosis surgery (whenever practical); (10) UV lights need NOT be used in the operating room; (11) patients should have intraoperative wound irrigation; (12) vancomycin powder should be used in the bone graft and/or the surgical site; (13) impervious dressings are preferred postoperatively; (14) postoperative dressing changes should be minimized before discharge to the extent possible.

Conclusions: In conclusion, we present a consensus-based BPG consisting of 14 recommendations for the prevention of SSIs after spine surgery in high-risk pediatric patients. This can serve as a tool to reduce the variability in practice in this area and help guide research priorities in the future. Pending such data, it is the unsubstantiated opinion of the authors of the current paper that adherence to recommendations in the BPG will not only decrease variability in practice but also result in fewer SSI in high-risk children undergoing spinal fusion.

Level of Evidence: Not applicable.

Key Words: spine, scoliosis, high risk, infection, SSI, surgical site infection, outcomes, guideline

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Perioperative surgical site infections (SSIs) after pediatric spine fusion are a well-described complication with rates ranging from 0.5% to 1.6% in idiopathic scoliosis to 3.7% to 8.5% in series that combine idiopathic and nonidiopathic diagnoses.[1–5] However, some patient populations are at an increased risk for SSIs after spinal fusion; SSI rates for patients with myelodysplasia range from 8% to 41.7%[6–12] and for those with cerebral palsy range from 6.1% to 15.2%.[13–18] SSIs impose a tremendous burden on the health and well-being of patients and their families, and carry a significant cost to the health care system.[19] As such, defining the risks associated with SSIs and utilizing appropriate measures to reduce these risks are critical.

Previous studies have determined numerous risk factors for SSIs including: suboptimal perioperative antibiotic timing,[4,20] age,[21] body mass index,[4,21,22] transfusions,[23] prolonged duration of surgery,[21,24] hypothermia,[4] fusion level,[24] not using postoperative drains,[23] serum glucose levels,[21] instrumentation to the pelvis,[5] and underlying etiology of scoliosis.[5,23–25] Many of these represent potentially modifiable risk factors that should be considered when designing an effective SSI prevention protocol. As consistently higher SSI rates have been documented in children with neuromuscular scoliosis when compared with idiopathic scoliosis,[5,26] efforts should be focused on this high-risk population. For the purpose of this effort, high risk was defined as anything other than a primary fusion in a patient with idiopathic scoliosis without significant comorbidities.

Considerable variation exists in infection prevention practices for spine surgery by the center and by the surgeon (Unpublished data, Glotzbecker MP, Vitale MG, Shea KG, et al.). This variation most likely reflects different training and expertise and gaps in the available evidence regarding various potential approaches. However, unexplained variation often reflects suboptimal care and should be limited when possible. Clinical practice guidelines rely on published evidence to determine the strength and grade of support behind specific interventions. In efforts to address the need to identify best practices, we first conducted a systematic literature review of preventive strategies for SSIs after pediatric spine surgery. Unfortunately, currently available literature is insufficient in methodological quality to support an evidence-based clinical practice guideline.[27] The current best practice guideline (BPG) therefore relies heavily on the consensus expert opinion of participants.

The current initiative seeks to draw both on the available literature and the experience and perspective of a group. In this study, we describe the process in which the systematic review was used by practiced pediatric spine surgeons and pediatric infectious disease specialists to inform the consensus-based development of a BPG using an iterative nominal group technique.

METHODS

Study Design: Overview of Consensus Process

To identify potential SSI prevention strategies for high-risk patients, we performed a systematic review of the literature using published guidelines to grade the level of evidence.[27–29] The primary authors (M.G.V., M.D.R., M.P.G., L.S.) created an electronic survey exploring the use of selected SSI prevention strategies (described below) by pediatric spine surgeons. In a face-to-face meeting, the survey results were discussed with respondents and consensus statements recommending the use of these selected strategies were crafted by the primary authors. The Delphi method was then used to create a consensus-based BPG to prevent SSIs after spine surgery in high-risk patients.[30] Briefly, the Delphi method is a validated system of developing consensus through repeated administrations of consensus statements that are modified after rounds of discussion. Respondents may change their responses to consensus recommendations based on the discussions and/or rewording of the recommendations.

Consensus Participants

Twenty experienced spine surgeons from the various children's hospitals in North America were asked to participate in this effort. Surgeons were selected because of clinical experience, a track record of relevant research, and experience in positions of leadership in various academic pediatric orthopaedic and spine organizations and study groups. In addition, 3 pediatric infectious disease subspecialists with expertise in SSI prevention were asked to participate in the consensus process.

Initial Survey of Current Practices

A 25-item online survey (SurveyMonkey) was administered to the participating spine surgeons in February 2012. Respondents were asked to provide the number of years they have been in practice, their annual number of scoliosis surgical cases, and their institution's SSI rates after spine surgery. Respondents were also asked to identify the preoperative, intraoperative, and postoperative SSI prevention strategies that they currently used for their high-risk patients as presented in Table 1. In addition, respondents were asked if they were willing to adopt specific prevention strategies for high-risk patients (if these practices were not currently in use), using a Likert scale (very willing, somewhat willing, not very willing).

Delphi Method: Consensus Round 1

Results of the systematic literature review and the results of the current practice survey were presented to the consensus participants at a face-to-face meeting in March 2012. After presentation of each potential SSI prevention strategy, participants were asked to share their perspective about the feasibility and importance of implementing the relevant strategy.

A second survey of 30 consensus statements was then created by the primary authors (M.G.V., M.D.R., M.P.G., L.S.) as shown in Table 2. A 4-point Likert scale was used to determine if respondents strongly agreed, agreed, disagreed, or strongly disagreed with these statements. Anonymous responses of all consensus participants were collected using the Audience Response System (ARS) whereby each participant was given a handheld device with which to enter their responses that were recorded electronically, tallied using a wireless computer program, and displayed to respondents in real time. To include or exclude a specific intervention in the BPG required that $\geq 80\%$ of respondents selected "strongly agree or agree" or selected "strongly disagree or disagree."

TABLE 1. Electronic Survey of Current Practices

1. Do you use a skin antiseptic (eg, chlorhexidine) wash the night before surgery?
2. Do you obtain preoperative urine cultures and treat if positive?
3. Do you routinely obtain nasal swabs for *Staphylococcus aureus* and treat if positive?
4. Do you provide patients written educational material preoperatively?
5. Do you assess nutritional status preoperatively? (ie, measure albumin, prealbumin)
6. Do you use intravenous cefazolin routinely for perioperative prophylaxis for scoliosis surgery?
7. Do you use intravenous vancomycin routinely for perioperative prophylaxis for scoliosis surgery?
8. Do you use an agent with activity against gram-negative pathogens routinely for perioperative prophylaxis for scoliosis surgery?
9. Do you formally monitor adherence to perioperative antibiotic prophylaxis protocol (ie, agent, timing, dosing, redosing, duration) for scoliosis surgery?
10. Would you be willing to implement a different antibiotic regimen based on literature or consensus-driven findings?
11. Do you remove hair from the operative site?
12. Do you limit access to the operative room during scoliosis surgery?
13. What type of wound irrigation do you use?
14. Do you routinely use vancomycin powder in the operative site?
15. Do you routinely have Plastic Surgeon perform closure of scoliosis surgery cases?
16. Do you add antibiotics to the graft?
17. Do you use ultraviolet light sources in the operative room?
18. What type of postoperative dressing do you use?
19. How often do you examine the wound and replace the dressing postoperatively?

TABLE 2. Consensus Round 1 for Best Practice Guidelines: Potential Interventions to Prevent Surgical Site Infections in High-risk Pediatric Spine Surgery

1. Patients should have a chlorhexidine skin wash the night before surgery.
2. Patients should have preoperative urine cultures obtained.
3. Patients should have preoperative nasal swabs for methicillin-resistant *Staphylococcus aureus*.
4. Patients should receive a preoperative Patient Education Sheet.
5. Patients should have a preoperative nutritional assessment.
6. Hair should be removed from the operative site (using clippers).
7. Chlorhexidine-based perioperative skin preparation is the preferred regimen.
8. Iodine-based perioperative skin preparation is the preferred regimen.
9. Patients should receive perioperative intravenous vancomycin.
10. Patients should receive perioperative intravenous cefazolin.
11. Patients should receive perioperative intravenous prophylaxis for gram-negative bacilli.
12. Adherence to perioperative antimicrobial regimens should be monitored.
13. Titanium/cobalt-chrome implants should be used preferentially.
14. Access to the operative room should be limited during scoliosis surgery.
15. Ultraviolet lights should be used in the operative room.
16. Patients should have intraoperative wound irrigation.
17. Saline alone should be used for wound irrigation.
18. Betadine should be included in the wound irrigation solution.
19. The pulsatile technique should be used for wound irrigation.
20. Vancomycin powder should be used in the surgical site.
21. Vancomycin should be added to the graft.
22. Gentamicin should be added to the graft.
23. A plastic surgeon should routinely assist with wound closure.
24. Postoperative subcutaneous drains should be used.
25. Gauze should be used for postoperative dressings.
26. "Silver"-impregnated dressings should be used for postoperative dressings.
27. Io-ban should be used for postoperative dressings.
28. Postoperative dressings should be changed once before discharge.
29. Postoperative dressing should be changed every other day before discharge.
30. Postoperative dressings should be changed daily before discharge.

Delphi Method: Consensus Round 2

Results from the first round were presented to participants in a face-to-face meeting the following day. Recommendations near consensus (70% to 79% agreement or disagreement) and those considered indeterminate (< 70% agreement or disagreement) were discussed and modifications to change wording were solicited to improve consensus. In addition, the potential to broaden or combine closely related guideline statements was discussed to increase consensus and flexibility

TABLE 3. Consensus Round 2: Revisions to Selected Interventions for Best Practice Guidelines: Potential Interventions to Prevent Surgical Site Infections in High-risk Pediatric Spine Surgery*

1. *If removing hair*, clipping is preferred to shaving.
2. Hair removal from the operative site should *be avoided*.
3. *When compared with other skin preparations*, chlorhexidine-based perioperative skin preparation is the preferred regimen.
4. Vancomycin powder should be *used in the bone graft and/or the surgical site*.
5. *Impervious dressings* are preferred postoperatively.
6. Postoperative dressing changes should be *minimized* before discharge.

*Word changes are shown in italics.

for implementation. Revised guideline statements as shown in Table 3 were presented to participants and anonymous responses recorded using the ARS. Statements with $\geq 80\%$ consensus were included or excluded in the BPG. Participants were then asked through ARS to respond "yes or no" (1) to support the publication of this BPG; (2) to implement the consensus recommendations in their practice; and (3) to participate in a prospective study of implementation of the BPG and its effectiveness.

RESULTS

Characteristics of Participants

The participation rate in the survey of current practices was 100%; all 20 pediatric spine surgeons completed the survey. Overall, respondents had a mean of 18.7 years (range, 2 to 37 y) in practice and had performed a mean of 130.5 spine surgeries (range, 20 to 400) in 2011 of which 55.8% (range, 25% to 95%) had been performed in high-risk patients. The mean self-reported SSI rate was 2.45% (range, 0% to 6.67%) when all patients (idiopathic and high risk) were combined.

Survey of Current Practices

Only one preventive practice was used by $\geq 80\%$ of respondents; 89.5% used intravenous cefazolin as perioperative antimicrobial prophylaxis for all spine surgery patients (including high risk). In addition, one practice was *not* used by $\geq 80\%$ of respondents; 100% of participants did not use ultraviolet lights in the operative room.

Delphi Method

After presentation of the current practice survey, the systematic literature review,[28] and discussion, the first consensus round produced 10 interventions that reached consensus shown in Table 4. Interventions that were near consensus (70% to 79%) included: patients should have preoperative nasal swabs for methicillin-resistant *Staphylococcus aureus* (74% disagreed or strongly disagreed); chlorhexidine-based perioperative skin preparation is the preferred regimen (78% agreed or strongly agreed); patients should receive perioperative intravenous vancomycin (70% disagreed or strongly disagreed); vancomycin powder should be used in the surgical site (74% agreed or strongly agreed); vancomycin should be added to the bone graft (70% agreed or strongly agreed); and postoperative dressings should be changed once before discharge (73% agreed or strongly agreed).

Indeterminant consensus (< 70% consensus) was reached for the following interventions: hair should be removed from the operative site using clippers (52% agreed or strongly agreed); iodine-based perioperative skin preparation is the preferred regimen (69% disagreed or strongly disagreed); titanium/cobalt chrome implants should be used preferentially (68% disagreed or strongly disagreed); preference for the type of intraoperative irrigation (52% preferred saline and 39% preferred dilute betadine solution); wound irrigation should be performed using the pulsatile technique (52% agreed or strongly agreed); gentamicin should be added to the bone graft (61% disagreed or strongly disagreed); postoperative subcutaneous drains should be used (61% agreed or strongly agreed); and preference for the type of postoperative dressing (48% preferred gauze dressings; 52% preferred iodine-based gauze dressings, 30% preferred silver-impregnated gauze dressings).

After further discussion, interventions not initially reaching consensus were broadened and revised as necessary as shown in Table 3 and a second consensus round lead to consensus for 4 additional interventions as shown in Table 4. Thus, consensus was reached for 14 prevention interventions that constituted the BPG (Table 4) and 9 interventions that did not reach consensus as shown in Table 5.

Upon review of the final BPG, 100% of the participants agreed to support its publication, implement the protocol at their respective institutions, and participate in a study of its use in high-risk patients.

DISCUSSION

As in so many areas of clinical medicine, available literature in this area lacks the methodological rigor to alone support a practical and useful clinical practice guideline.[28] Nevertheless, significant documented variability in current practice in the approach to SSI prevention for high-risk spine surgery patients demands attention.[27] Use of a nominal group technique to formally develop consensus among experienced clinicians has the potential to harness "the power and judgment of the group" and has been described in multiple settings.[31–33] The current initiative utilized the available literature evidence to guide expert opinion and, for the first time, develop consensus regarding 14 practices to represent what the authors believe to be current "best practice" in pediatric spine surgery SSI prevention for high-risk patients.

Using the nominal group technique, supplemented by the survey of current practices and systematic literature review, participants reached consensus based on their interpretation of the literature (often available in other surgical populations), their experience and practice patterns, and/or the face-to-face discussions held during the Delphi process. We propose that *collective knowledge*[30] played a large role in the consensus process as the

TABLE 4. Final Best Practice Guidelines: Consensus Recommendations to Prevent Surgical Site Infections in High-risk Pediatric Spine Surgery

	Consensus (%)		
	Total	Strongly Agree	Agree
1. Patients should have a chlorhexidine skin wash at home the night before surgery.*	91	61	30
2. Patients should have preoperative urine cultures obtained and treated if positive.*	91	26	65
3. Patients should receive a preoperative Patient Education Sheet.*	91	48	43
4. Patients should have a preoperative nutritional assessment.*	96	57	39
5. If removing hair, clipping is preferred to shaving.†	100	61	39
6. Patients should receive perioperative intravenous cefazolin.*	91	65	26
7. Patients should receive perioperative intravenous prophylaxis for gram-negative bacilli.*	95	65	30
8. Adherence to perioperative antimicrobial regimens should be monitored (ie, agent, timing, dosing, redosing, cessation).*	96	61	35
9. Operating room access should be limited during scoliosis surgery whenever practical.*	96	61	35
10. Ultraviolet lights need not be used in the operating room.*	87	48	39
11. Patients should have intraoperative wound irrigation.*	100	83	17
12. Vancomycin powder should be used in the bone graft and/or the surgical site.†	91	48	43
13. Impervious dressings are preferred postoperatively.†	91	56	35
14. Postoperative dressing changes should be minimized before discharge to the extent possible.†	91	52	39

*These interventions reached consensus after the first round of voting.
†These interventions reached consensus after the second round of voting.

discussion sessions provided an opportunity for all participants to voice their knowledge and experience and learn from the knowledge and experience of others.

The Delphi process substantially increased consensus for both including and excluding preventive practices.[30] In the initial survey of current practices, only 2 strategies reached consensus; $\geq 80\%$ of respondents used intravenous cefazolin as perioperative prophylaxis and $\geq 80\%$ did not use ultraviolet lights in the operative room. Consensus for use of cefazolin is not surprising as this agent is considered the standard of care and recommended by guidelines developed by the American Academy of Orthopaedic Surgery (http://www.aaos.org/about/papers/advistmt/1027.asp). After one round of seeking consensus, participants agreed upon 10 practices. After additional discussion and modifications to the wording of some recommendations, consensus was reached for an additional 4 interventions. The 14 interventions that comprise this BPG could serve as a first nationwide strategy aimed to reduce SSIs in high-risk pediatric patients undergoing spine surgery. Notably, consensus could not be reached for 9 interventions implying collective but not individual equipoise for these measures, perhaps highlighting opportunities for experimental research.

Participants reached consensus to include 4 preoperative interventions in the BPG. Performing a chlorhexidine-gluconate (CHG) skin wash the night before surgery and providing a Patient Education Sheet

TABLE 5. Interventions to Prevent Surgical Site Infections in High-risk Pediatric Spine Surgery That Did NOT Reach Consensus for Inclusion in Best Practice Guidelines

	Responses (%)				
Intervention	Summary	Strongly Agree	Agree	Disagree	Strongly Disagree
1. Patients should have preoperative nasal swabs for methicillin-resistant *S. aureus*.	74% disagree	9	17	61	13
2. Hair removal from the operative site should *be avoided.*	60% disagree	0	40	60	0
3. *When compared with other skin preparations*, chlorhexidine-based perioperative skin preparation is the preferred regimen.	62% agree	24	38	33	5
4. Patients should receive perioperative intravenous vancomycin.	70% disagree	4	26	57	13
5. Titanium/cobalt-chrome implants should be used preferentially.	68% disagree	5	27	50	18
6. Saline *alone* should be used for wound irrigation.	52% agree	9	43	48	0
7. The pulsatile technique should be used for wound irrigation.	52% agree	26	26	35	13
8. Gentamicin should be added to the bone graft.	61% disagree	13	26	57	4
9. Postoperative subcutaneous drains should be used.	61% agree	35	26	26	13

regarding the risks of infection and how to avoid them are low risk to the patient and relatively easy to implement, the latter of which is consistent with Joint Commission National Patient Safety Goals (http://www.jointcommission.org/assets/1/18/Patient_Safety_1_14_11.pdf). In contrast, preoperative screening for nutrition status and urinary tract infections is more complex to coordinate and may require collaboration with other specialties. Nonetheless, as found in our systematic review, malnutrition[12,34] and urinary tract infections[12,35] are both potentially modifiable risk factors for SSIs.

Nine intraoperative strategies were included in the BPG and most focused on recommendations for antimicrobial prophylaxis and monitoring adherence to these recommendations; failure to administer prophylaxis within the 60 minutes before incision has been associated with SSIs.[3,4,20] In addition to the use of cefazolin, consensus was reached to include antimicrobial prophylaxis for gram-negative pathogens plus the use of topical vancomycin in the operative site and/or bone graft. Although gram-negative pathogens are increasingly reported to cause SSIs in high-risk patients, especially those with neuromuscular disease,[1,3–5,36,37] adding prophylaxis for gram-negative pathogens will represent a substantial change in practice as only 48% of respondents reported they used this preventive strategy in the survey of current practices.[27] Consensus was not reached on the use of gentamicin in the bone graft although one study has demonstrated possible benefit.[18] As skin flora has become increasingly resistant to cefazolin, for example, methicillin-resistant *S. aureus* (MRSA) and methicillin-resistant coagulase-negative staphylococci, there is increasing rationale to add topical vancomycin. Among adult patients undergoing spine surgery, local application of vancomycin has been shown to reduce the risk of SSIs.[38–41] Notably, 70% of participants disagreed that intravenous vancomycin should be used as prophylaxis in part due to the complexity and potential toxicity of administering intravenous vancomycin preoperatively (http://www.biomedcentral.com/content/pdf/cc1871.pdf), and questioning whether it would have additive benefit when topical vancomycin is being used. Participants agreed that clipping was preferred to shaving if removing hair, but this recommendation had been modified as not all participants agreed that hair removal was necessary. Finally, participants agreed that operating room access should be limited during spine surgery "to the extent practical," but a more precise definition to guide this recommendation was not developed.

The 2 postoperative BPG recommendations included the use of impervious dressings and minimizing dressing changes before hospital discharge in acknowledgment of high rates of urinary and fecal incontinence. Consensus could not be reached about the particular type of dressing that should be used, reflective of both personal preference and individual institutional purchasing.

Participants could not reach consensus for interventions shown to be effective at reducing SSIs in other surgical populations. Fewer than 80% of participants disagreed that preoperative surveillance for MRSA should be performed citing lack of data supporting an appropriate response to positive cultures or supporting the cost effectiveness of this practice. Although the Infectious Disease Society of America and Society for Healthcare Epidemiology of America determined that screening for MRSA was an unresolved issue due to inconclusive findings,[42] other studies have shown that screening and eradication of *S. aureus* is associated with a reduction in SSIs.[43] Fewer than 80% agreed that CHG should be recommended for surgical skin preparation. Although a randomized clinical trial comparing CHG-alcohol to povidone-iodine (betadine) demonstrated that rates of superficial and deep SSIs in clean-contaminated gastrointestinal, thoracic, gynecologic, and urologic procedures were significantly lower in the CHG-alcohol group,[44] in adult patients undergoing spine surgery, CHG-based and iodine-based skin preparations were associated with similar SSI rates.[45] Furthermore, although participants largely agreed that CHG had been shown to be efficacious, some were concerned that this disinfectant hindered the adhesion of an io-ban barrier placed before surgery. In addition, participants were concerned about chemical burns of eyes and skin and fires related to CHG. Intraoperative factors agreed upon including the use of intraoperative wound irrigation, but as this is standard of care for most surgical wounds, this does not likely represent a change in practice. A discussion on wound irrigation technique revealed that participants' practices varied greatly because of no evidence in this field for specific irrigation method. There is some evidence in the adult spinal literature that dilute betadine irrigation before closure may reduce the rate of spinal infections.[46–49] However, this has not been applied to the pediatric population and the group was split nearly 50%-50% both on using saline-only or dilute betadine/disinfectant during the washout and pulsatile versus continuous washout techniques.

Consensus was not reached for the type of implant. Some evidence suggests that titanium implants may confer some protection against delayed SSI,[50,51] presumably mediated by differences in the way biofilms form on various metals.[52] However, participants expressed the importance of selecting the type of rod used and were concerned that evidence was limited to support a specific type of implant. Similarly, although one study has suggested that postoperative drains may reduce infections,[10] participants could not reach consensus in part due to personal practices and preferences.

Equally important, perhaps, there are several areas where there seems to be near complete group equipoise with regard to perioperative management. For example, roughly half of the group felt that a dilute betadine irrigation should be used before wound closure. Such equipoise highlights opportunities for prospective randomized trials.

There are several limitations to the development of this BPG. As mentioned, there is a lack of literature that subsequently limits our abilities to make evidence-based recommendations based on well designed comparative studies. Furthermore, while we included nonpediatric

literature in discussions during the Delphi process, it remains uncertain if such studies are relevant for the high-risk pediatric population. The definition of "high risk" is not fully established. Finally, some of the recommendations are relatively vague, for example, limit traffic in the operating room, which would make monitoring adherence very difficult.

In conclusion, we present a consensus-based BPG for the prevention of SSIs after spine surgery in high-risk pediatric patients. This was derived through a combination of review of the available literature evidence and the expert opinion, formally integrated toward consensus through a nominal group technique. Participants reached consensus regarding14 SSI prevention strategies. Participants have agreed to implement the BPG protocol and participate in a prospective study assessing its effectiveness and feasibility. Pending such data, it is the unsubstantiated opinion of the authors of the current paper that adherence to recommendations in the BPG will not only decrease variability in practice but also result in fewer SSI in high-risk children undergoing spinal surgery.

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