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Measures to Prevent Surgical Site Infections: What Surgeons (Should) Do

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Abstract
Background The present study was designed to evaluate surgeons' strategies and adherence to preventive measures against surgical site infections (SSIs).
Materials and methods All surgeons participating in a prospective Swiss multicentric surveillance program for SSIs received a questionnaire developed from the 2008 National (United Kingdom) Institute for Health and Clinical Excellence (NICE) clinical guidelines on prevention and treatment of SSIs. We focused on perioperative management and surgical technique in hernia surgery, cholecystectomy, appendectomy, and colon surgery (COL).
Results Forty-five of 50 surgeons contacted (90%) responded. Smoking cessation and nutritional screening are regularly propagated by 1/3 and 1/2 of surgeons, respectively. Thirty-eight percent practice bowel preparation before COL. Preoperative hair removal is routinely (90%) performed in the operating room with electric clippers. About 50% administer antibiotic prophylaxis within 30 min before incision. Intra-abdominal drains are common after COL (43%). Two thirds of respondents apply nonocclusive wound dressings that are manipulated after hand disinfection (87%). Dressings are usually changed on postoperative day (POD) 2 (75%), and wounds remain undressed on POD 2–3 or 4–5 (36% each).
Conclusions Surgeons' strategies to prevent SSIs still differ widely. The adherence to the current NICE guidelines is low for many procedures regardless of the available level of evidence. Further research should provide convincing data in order to justify standardization of perioperative management.

Introduction

Surgical site infections (SSIs) represent a quarter of all nosocomial infections and affect up to 5% of all surgical [1–3]. They prolong hospital stay by about 10 days, with a 2–3-fold increase in costs [4–6]. Several risk factors for SSI have been identified; some are inherent in the patient or the intervention. Some may be corrected; others, not. Acknowledged patient-related risk factors for SSI are age, underlying illness (like diabetes), obesity, smoking, malnutrition, steroid use, and immunosuppression [2, 7–11]. Procedure-related issues concern mainly the anesthetist and the surgeon and include antibiotic prophylaxis, oxygen supply, fluid management, and skin disinfection [11–17]. Probably the single most important risk or protective factor for SSI is the surgeon. However, the surgeon's impact on the incidence of SSIs has not yet been examined in a comprehensive manner [11, 18–20].

Michele Diana and Martin Hübner share first authorship.

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A multitude of actions have been suggested in attempts to reduce SSI risks. Most of these measures have recently been scrutinized by expert panels, and American and British guidelines have been published giving evidence-based recommendations [2, 21]. Unfortunately, recommendations on specific surgical measures remain vague, and other potentially important surgical strategies are not mentioned at all. Furthermore, little information is available on the implementation of the newly formulated recommendations.

We aimed therefore to assess comprehensively the current perioperative strategies of surgeons in western and southern Switzerland and to compare established policies with evidence-based guidelines for the prevention of SSI.

Materials and methods

All active surgeons participating in a prospective multicentric surveillance program for SSIs in western and southern Switzerland were asked to participate in the present study. Sixteen of the 50 surgeons contacted were affiliated with one university hospital, and 34 were affiliated with 10 different secondary care hospitals.

Respondents' surgical strategies with regard to SSI prevention were assessed by a standardized 56-item multiple-choice questionnaire (Appendix 1 in Supplementary material). Items to explore were drawn mainly from the recently published National (United Kingdom) Institute for Health and Clinical Excellence (NICE) guideline [1, 21] with emphasis on perioperative behavior and surgical technique (Table 1). These recommendations are based on a systematic review of the available evidence or—if not available—on the consensus of the underlying expert panel. Question 19 on preoperative skin disinfection was imprecise, as both iodine-based and chlorhexidine-based skin disinfectants may contain alcohol. Therefore, skin disinfection was not among the items analyzed.

Perioperative behavior is doubtless subject to change over time and is therefore likely to depend on the surgeon's age and experience. We therefore stratified the responding surgeons by their surgical experience (less or more than 10 years since their specialty board) and compared these two different "generations" of surgeons in terms of perioperative strategies employed to prevent SSIs.

Statistical analysis was performed with a standard software package, SPSS 14.0 (SPSS, Inc., Chicago, IL). Descriptive statistics are expressed as absolute numbers or percentages. Fisher's exact test was used for comparison of discrete variables. A P value of less than 0.05 was considered statistically significant.

Results

Overall, 45 of the 50 contacted surgeons (90%) answered the questionnaire, 15 working in the university center and 30 working in the various secondary care hospitals. Their median time from surgical board was 13 years (range: 1–31 years). A complete summary of answers can be found in Supplementary material (Appendix 2). The most pertinent findings are presented here.

Preoperative phase

Around 40% of the responding surgeons do not advocate preoperative smoking cessation at all before elective hernia surgery (HER), cholecystectomy (CCE), and colon surgery (COL) (Fig. 1a). Nutritional screening is regularly conducted by about 50% of surgeons before major surgery (COL), as shown in Fig. 1b. Before COL bowel preparation is always required by 15%, sometimes required by 26%, and rarely required by 30%, whereas 26% have abandoned it completely. Fifty-seven percent of the surgeons routinely recommend a preoperative antiseptic shower, and 75% require umbilical cleansing, without any

Table 1 Relevant factors with regard to surgical site infections (SSI)

Summary of key factors that have been associated with the incidence/prevention of surgical site infections [2, 21] and that have therefore been integrated in the present questionnaire

Preoperative phase	Intraoperative phase, technique
Smoking cessation	Skin disinfection
Nutritional screening	Use of laparoscopy
Bowel preparation	Surgical drapes
Preoperative hygiene	Use of adhesive drapes
Hair removal	Surgical gloves (double, change)
Operating room staff: exclusion/limitation	Intracavitary lavage
Antibiotic prophylaxis	Wound irrigation
Postoperative phase	Intra-abdominal drains
Postoperative antibiotic therapy	Subcutaneous drains
Wound dressing	Drains: type, removal
Dressing change	Closure (fascia, subcutaneous, skin)

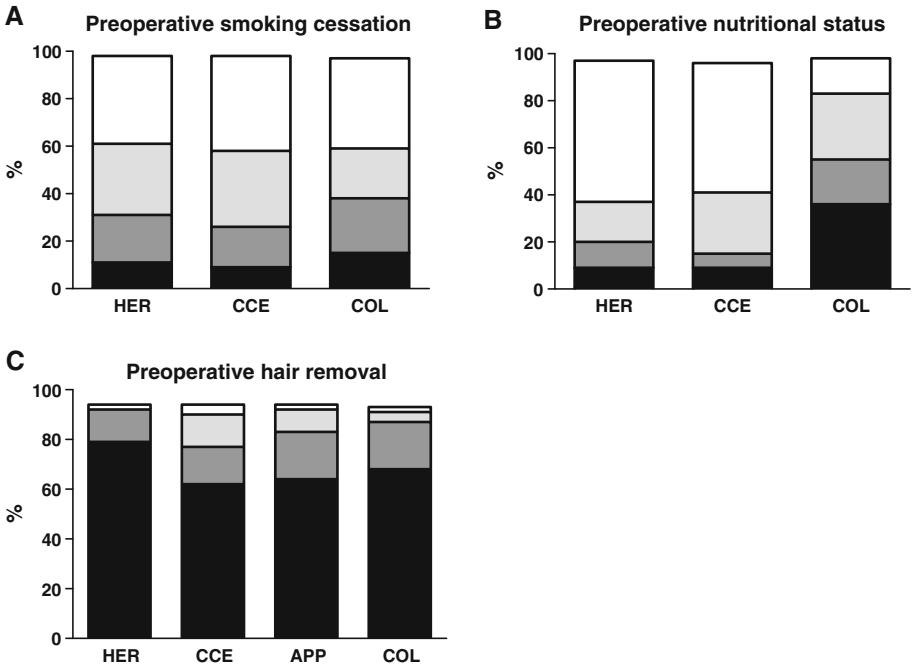

Fig. 1 Preoperative measures associated with the prevention of surgical site infections: counselling on smoking cessation, nutritional screening and preoperative shaving. Values are percentages for hernia surgery (*HER*), cholecystectomy (*CCE*), appendectomy (*APP*), and colectomy (*COL*). Counseling on preoperative smoking cessation (**a**), preoperative nutritional screening (**b**), and preoperative shaving (**c**) are performed by the responding surgeons always (*black*), sometimes (*dark gray*), rarely (*light gray*), or never (*white*)

significant differences between the different types of operations. Most of the surgeons request preoperative shaving regardless of the type of operation (Fig. 1c). Shaving is carried out in the operating room (OR) with electric clippers by 90% of the surgeons responding. Actual practice with regard to antibiotic prophylaxis is displayed in Fig. 2a. More than half of the surgeons administer preoperative antibiotics less than 30 min (45–49%) or more than 60 min (6%) before incision, regardless of the type of operation. Cephalosporins are the most widely applied antibiotic (coupled with metronidazole in APP and COL), but penicillines are still used in patients undergoing APP and COL (Fig. 2b). Additional doses are used in prolonged COL procedures after 3 h (11%), 4 h (55%), or 6 h (32%). The great majority of surgeons do not routinely use postoperative antibiotics. When prescribed, the duration of their use increases with the degree of contamination of the operative site (Fig. 2c and d).

Intraoperative phase, technique

Nearly 100% of the responding surgeons use disposable surgical drapes, and the drapes are usually changed during the procedure (Fig. 3a). Adhesive drapes (30% with antiseptic impregnation) are popular in HER but are rarely used in CCE and APP (Fig. 3b)—procedures that are mainly performed by a laparoscopic approach (Fig. 3b). Ninety percent of the surgeons never or rarely use two pairs of gloves. Gloves are usually changed before mesh inlay (66%) and during COL after 2 h (40%) or 4 h (38%). Rinsing of the operative site (deep, subcutaneous) is clearly correlated with the type of operation. Most surgeons rinse the surgical site with saline, and 23% of surgeons use iodine for rinsing the subcutaneous layer after APP and COL (Table 2). Skin disinfection before and after skin closure is routinely performed by 73 and 66% of the surgeons, respectively, with no difference between the four analyzed procedures. Some 80% of surgeons prefer iodine-based solutions. Intra-abdominal drains are rarely placed after CCE and APP, and if used, they are removed early in the postoperative period. In contrast, intra-abdominal drains are always placed after COL by 21% of surgeons and never by 6% (Fig. 4a and c). Up to 51% of surgeons leave a drain after heavily contaminated (class IV) APP or COL. Subcutaneous drains are placed only exceptionally (Fig. 4b) and are removed on postoperative day (POD) 1–2 after the operation. Most surgeons divert drains to a point distant from the skin incision. While closed-suction drains are clearly preferred for subcutaneous drainage, about half of the responding surgeons choose an open system for intra-abdominal drains (Appendix 2, in Supplementary material). Techniques for fascia closure and subcutaneous and skin closure are summarized in Table 3. Subcutaneous closure has been largely abandoned, and running loop closure of the fascia and staples are established habits after laparotomy (COL). Delayed primary closure is rarely or never performed after APP and COL by 79 and 64% of the surgeons, respectively.

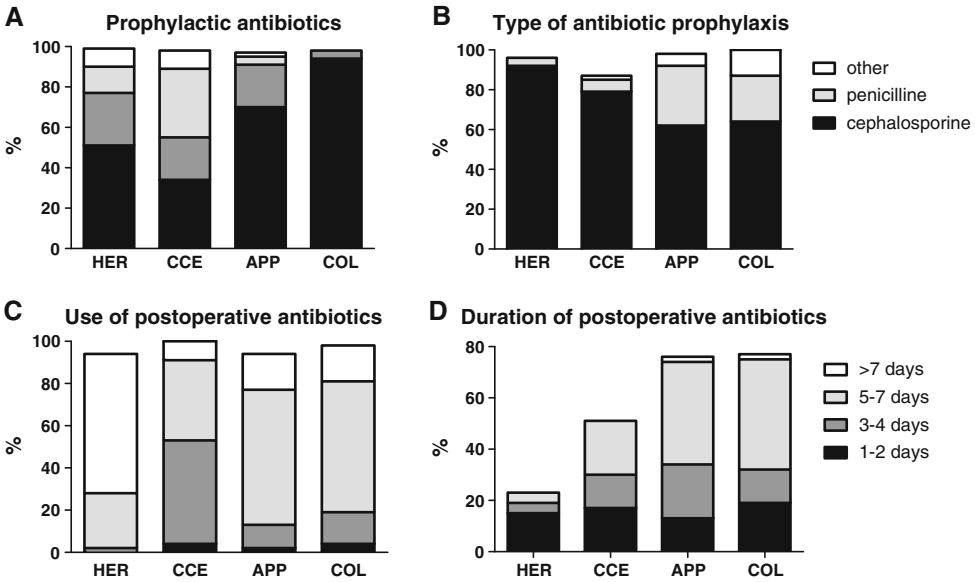

Fig. 2 Preoperative and postoperative use of antibiotics by type of operation. Values are percentages for hernia surgery (*HER*), cholecystectomy (*CCE*), appendectomy (*APP*), and colectomy (*COL*). Antibiotic prophylaxis (**a**) and postoperative treatment (**c**) are given by the responding surgeons always (*black*), sometimes (*dark gray*), rarely (*light gray*), or never (*white*). Habits concerning type of antibiotics and duration of postoperative treatment are given with the respective legends in (**c**) and (**d**)

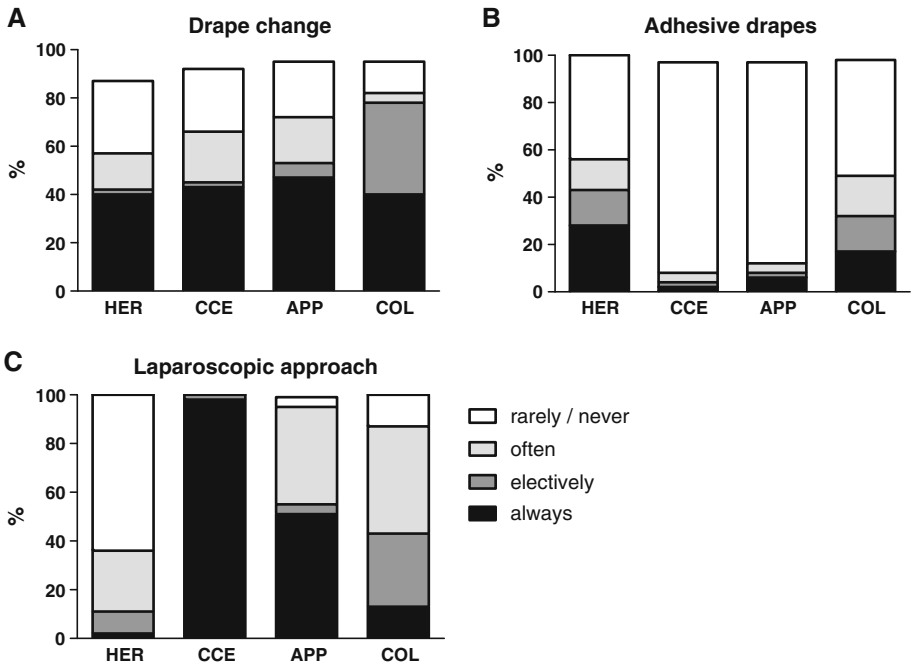

Fig. 3 Intraoperative measures associated with the prevention of surgical site infections: surgical drapes and use of laparoscopy. Values are percentages for hernia surgery (*HER*), cholecystectomy (*CCE*), appendectomy (*APP*), and colectomy (*COL*). Intraoperative changing of surgical drapes (**a**), use of adhesive drapes (**b**), and laparoscopy (**c**) are employed by the responding surgeons always (*black*), sometimes (*dark gray*), rarely (*light gray*), or never (*white*) or as indicated in the legend (**C**)

Postoperative phase

Wound dressings applied are mainly nonocclusive in usually noncontaminated (58% HER and CCE) and contaminated procedures (69% APP and COL). Dressing changes are performed after simple hand disinfection by 87% of the surgeons and under sterile conditions by 55% of the surgeons. Three quarters of the responding surgeons (range: 72–79%) perform the first dressing change on POD 2 and leave the wounds undressed on POD 2–3 (36%) or POD 4–5 (36%) without any significant difference between the surgical procedures.

Does surgical experience influence perioperative behavior?

Twenty of the responding surgeons had obtained their specialty board less than 10 years prior to the study, and 25 had done so 10 or more years before. Significantly more younger surgeons than older surgeons do not perform routine smoking cessation counseling before HER (85 vs. 53%; $P < 0.0001$), CCE (90 vs. 57%; $P = 0.002$), and COL (75 vs. 49%; $P = 0.007$). Younger surgeons administer more antibiotics before and after appendectomy (routine prophylaxis: 84 vs. 64%; $P = 0.029$; no postoperative

Table 2 Rinsing of the operative site by type of operation

	HER	CCE	APP	COL
Deep lavage				
Always/never	**51**/9	**60**/0	**79**/0	**83**/0
Saline/iodine	81/13	90/6	85/11	83/13
Irrigation sc				
Always/never	**55**/9	**58**/9	**72**/4	**79**/4
Saline/iodine	79/11	77/13	68/23	68/23

Values are percentages for hernia surgery (*HER*), cholecystectomy (*CCE*), appendectomy (*APP*), and colectomy (*COL*). *Boldface* indicates the trend for irrigation depending on the degree of contamination

sc subcutaneous

Table 3 Overview of closure techniques

Layer	HER	CCE	APP	COL
Fascia				
Polyfil/monofil	55/34	51/40	60/32	23/**70**
Running/interrupted	85/9	64/30	60/38	**85**/13
Subcutis				
Always/never	**51**/13	**13**/43	**19**/40	**15**/47
Running/interrupted	26/53	19/40	15/53	21/32
Skin				
Convent/intracut	36/49	49/38	57/30	28/28
Staples	11	11	9	43
Running/interrupted	55/40	32/62	28/68	28/66

Values are percentages for hernia surgery (*HER*), cholecystectomy (*CCE*), appendectomy (*APP*), and colectomy (*COL*)

Polyfil/monofil poly-/monofilament; *Running/interrupted* running/interrupted suture technique; *Convent* conventional; *intracut* intracutaneous

Key points are indicated in *boldface*

treatment: 70 vs. 100%; $P = 0.011$), and prefer cephalosporines and metronidazole over penicillines as prophylaxis in COL (85 vs. 52%: $P = 0.042$). Furthermore, glove changes are more common among the "younger generation" after intraoperative contamination during CCE and APP (60 vs. 27%; $P = 0.033$; and 65 vs. 31; $P = 0.034$). Interestingly, we found no difference between the two groups of surgeons, "younger versus older," with regard to recently reviewed "hot topics," such as nutritional screening, bowel preparation, hair removal, and intra-abdominal drains.

Discussion

The present study provides evidence that perioperative surgical care varies widely, even in a relatively homogeneous group of general surgeons from the same geographic region. Actual policies differ considerably from evidence-based guidelines for the prevention of SSI, irrespective of the surgeon's experience.

Numerous risk factors for SSI have been associated with the patient, the intervention, and the behavior of the surgical team and the anesthesia team [2, 3, 6–10, 15, 16, 20, 22, 23]. From a practical point of view, modifiable risk factors are the most appealing. Many of them are discussed in the most recent NICE guideline [1, 21]. But, interestingly from a scientific point of view, many recommendations of this

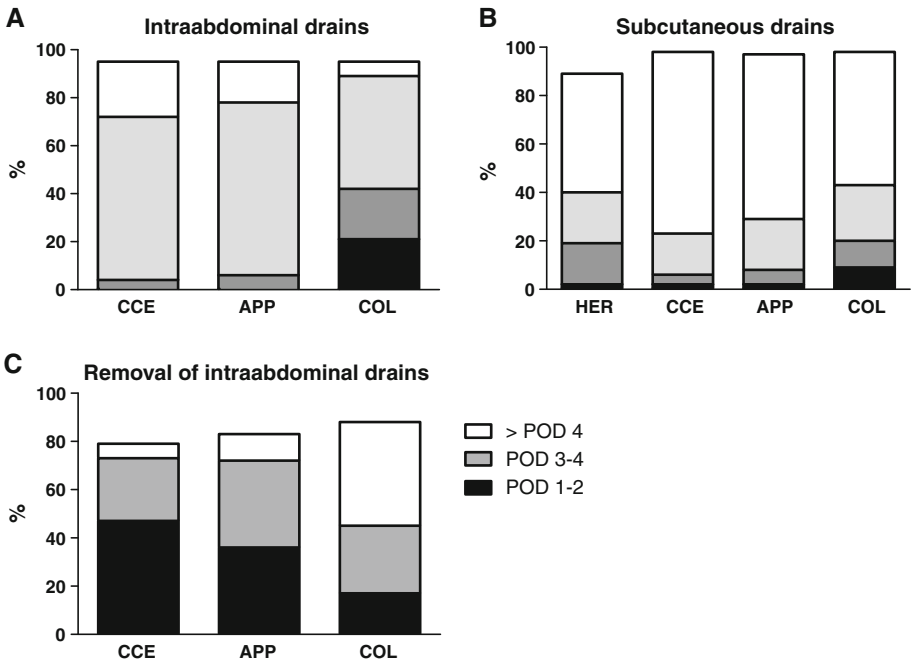

Fig. 4 Drains in or drains "out"? Values are percentages for hernia surgery (*HER*), cholecystectomy (*CCE*), appendectomy (*APP*), and colectomy (*COL*). Intra-abdominal (**a**) and subcutaneous drains (**c**) are placed by the responding surgeons always (*black*), sometimes (*dark gray*), rarely (*light gray*), or never (*white*). Removal of intra-abdominal drains occurs variably around postoperative day (POD) 2–4 (**C**)

Table 4 Summary of actual recommendations for the prevention of SSI [2, 21] compared with surgeons' adherence

Preventive item	NICE 2008 recommendations	LoEv	Adherence
Smoking cessation	Encourage … >30 days before surgery	2+	26–38
Nutritional status	Correct malnutrition before major surgery	2−	55
Bowel preparation	Do not use bowel preparation [26, 27]	1+	57
Antiseptic shower	Normal bar soap or chlorhexidine [28]	1+	62–68
Umbilical hygiene	"Perform umbilical hygiene"	n.a.	79–87
Hair removal	Do not perform routine hair removal	1+	2–17
Timing	… in operating room	1+	85–94
Instrument	… with electric clippers	1+	89–91
Infected staff	"Exclude infected members"	n.a.	43
Staff limitation	"Keep movements to minimum"	n.a.	57–75
Antibiotic prophylaxis	Clear indication for APP and COL	1+	70 [3], 94 [4]
Type	"Cephalosporines 1st choice"	n.a.	62–92
Timing	60–30 min before incision [29]	2+	34–47
Repeated dose	"Repeated antibiotic dose after 3 h"	n.a.	66 [4]
Skin disinfection	Povidone-iodine or chlorhexidine	1+	60
Surgical drapes	Reusable or disposable equivalent	1+	100 disp
Contamination	"Change drapes after contamination"	n.a.	43–79
Adhesive drapes	Do not use adhesive drapes [30]	1+	58–94
Type	Preferably with antiseptic impregnation	1+	6–21
Double gloving	… If high risk of contamination [31]	1−	9
Glove change			
Routine	No correlation: puncture rate—SSI	1−	38–79
Before mesh	"Change before mesh placement"	n.a.	66
Contamination	"Change in case of contamination"	n.a.	32–66
Routine laparoscopy	Laparoscopic approach preferable [32]	1−	85 [3, 4]–100 [2]
Intracavitary lavage	Do not use routine intracavitary lavage	1+	0 [3, 4]
Type	Saline and antiseptics equivalent	1+	81–89 saline
Wound irrigation (sc)	Do not use routine sc irrigation	1+	6–23
Type	Saline and antiseptics equivalent [33]	1+	68–79 saline
Skin disinfection			
Before closure	Not indicated [34]	1+	19–23
Type	Povidone-iodine	1+	85
After closure	"Not indicated"	n.a.	32
Type	"Use povidone-iodine" [33]	n.a.	79
Abdominal drains	Not indicated: CCE, APP, COL [35]	1−	53 [4]–92 [2, 3]
Contamination	No data	n.a.	51 [3, 4] for IV [36]
Type	"Closed suction devices preferable"	n.a.	30–45
Incision	"Place drains distant from incision"	n.a.	70–83
Removal	"Remove drain within 48 h"	n.a.	17 [4]–47 [2]
Subcutaneous drains	Do not use sc drains	1+	70–92
Type	"Closed suction devices preferable"	n.a.	86–92
Incision	"Place drains distant from incision"	n.a.	62–75
Removal	"Remove drain within 48 h"	n.a.	87–100
Fascia closure			
Running/separate	Use running suture [37]	1+	60–85
Monofil/polyfil	Monofilament maybe preferable	1+	32–70
Subcutaneous closure	No benefit of sc closure	1+	23 [1]–70 [4]
Running/separate	No data available	n.a.	60–78 sep.

Table 4 continued

Preventive item	NICE 2008 recommendations	LoEv	Adherence
Skin closure			
Delayed primary	"Perform delayed primary closure if necessary (contamination)"	1−	19 [3]–34 [4]
Running/separate	No difference	1−	28 [1]–55 [3, 4] rs
Technique	No difference staples, intracut, etc.	1+	variable
Postoperative antibiotics	"… If contamination class III–IV [36]"	n.a.	13 [3]–19 [4]
Duration	"3–4 day treatment rise the risk of SSI"	n.a.	42 [3, 4]
Wound dressing	Use nonocclusive dressing [38]	1+	57–70
Dressing change	"First change after 48 h"	n.a.	72–79
Leave undressed	… On day 2–3	1+	36–38
Dressing change	"Routine hand disinfection before …"	n.a.	87
Sterile technique	"Use sterile no touch technique"	1−	55

The actual recommendations are based mainly on the recently published exhaustive 2008 National (United Kingdom) Institute for Health and Clinical Excellence (*NICE*) guidelines for the prevention of SSI with its Levels of Evidence (*LoEv*) [21]. For specific items, (US) Centers for Disease Control and Prevention (*CDC*) guidelines [2] or pertinent original publications are referenced in addition. Recommendations with weak or nonexistent evidence in the literature are shown in *quotation marks* (LoEv: n.a.). The adherence of the responding surgeons to these guidelines is displayed as percentage for hernia surgery (HER: 1), cholecystectomy (CCE: 2), appendectomy (APP: 3), and colectomy (COL: 4)

n.a. not applicable

exhaustive review are based on quite fragile grounds, evidence being scarce for many recommendations in perioperative care, as already mentioned by other investigators [24, 25]. This could explain why surgeons don't want to implement all of these suggested measures in their clinical routine. Indeed, apart from antibiotic prophylaxis and laparoscopic approach, very few procedures seem to be followed consistently on a routine basis by the vast majority of respondents. Consequently, as detailed in Table 4, adherence to NICE guidelines varies widely, from an overall 100% for the use of surgical drapes to 0% for avoiding intracavitary lavage at the end of the intervention. Apparently, shifts in practice are rather reluctantly adopted if the recommendations are not backed up by solid scientific evidence, as was the case for 22/56 items analyzed in our survey. However, even guidelines based on strong evidence, such as those concerning the avoidance of preoperative shaving or intracavitary lavage, are difficult to adopt comprehensively.

Thus, the lack of standardization of surgeons' behavior seems somewhat idiosyncratic. It might be explained not only by the absence of evidence for many preventive measures but also by ignorance of evidence-based recommendations. Because noncompliance of accepted guidelines entails a worse outcome [18], this is worrying. Apparently, surgeons, even if they have obtained their board certification more recently, are reluctant to abandon old habits, such as preoperative bowel preparation or the use of adhesive drapes and abdominal drains, despite widely published counterarguments. On the other hand, intuitive measures without proven efficacy (e.g., repeated disinfection and drape change, double-gloving, wound irrigation) remain popular.

As shown by Beldi et al. in a recent randomized trial, other factors than mere implementation of preventive measures could play an important role in the occurrence of SSI [20]. By comparing patients who underwent surgery with "extensive antiseptic measures" to patients for whom only "standard measures" were used, these authors showed that lapses in discipline in the OR during surgery were independently associated with SSI, whereas no difference in SSI rates could be found between the two groups. Moreover, as stated by Mishriki, individual surgical skill certainly plays an important role, not necessarily linked to adherence to published guidelines [26]. However, discipline and surgical skill are more difficult to assess than adherence to recommendations, such as the best timing of antibiotic prophylaxis or the necessity of hair removal. A high surgeon operation volume, probably reflecting, in part, technical skills, has nevertheless been associated with lower SSI rates in the Dutch nosocomial infection surveillance network [19]. Cumulative experience, gained by years of practice, might also lower risks of SSI by enhancing surgical skill; however, as shown in our study, this would not necessarily be associated with a better adherence to published guidelines by senior surgeons.

Several limitations of this study need to be discussed. First, it included only a relatively small number of surgeons from Western and Southern Switzerland. Its results can therefore not be generalized to other settings where adherence to guidelines might be different. Given their voluntary participation in a surveillance program for SSI, we believe however that the participating surgeons were nonetheless sensitized to SSI risks. Second, the study was

based on a questionnaire and not on direct observation of practice, which, as shown by Beldi et al. [20], may show lapses, even in a comprehensive programme addressing the risks of SSI. It was not the objective of this present study to correlate actual behaviour in the OR with SSI rates. Third, the questionnaires used for this study, based on the NICE clinical guidelines [1], were sent shortly after their publication and not every Swiss surgeon might have been conversant with or feel concerned by these UK-originated guidelines. However, the recent (2008) guidelines do not fundamentally differ from those of the 1999 Centers for Disease Control [2], and many recommendations from the latter were still not followed by a substantial proportion of surgeons. There are no comparable Swiss guidelines.

In conclusion, the implementation of measures to prevent SSI varies greatly among surgeons, even in a relatively small geographic area in the same country. This could partly be explained by the lack of scientific evidence for many possible risk factors for SSIs. Clearly, future studies are needed to deliver convincing evidence for the use of individual measures in order to justify a standardisation of perioperative surgical management. Meanwhile, surgeons can already make efforts to implement preventive measures that are proven yet to prevent SSIs.

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