Journal of Visceral Surgery (2019) 156, 413—422

Available online at ScienceDirect www.sciencedirect.com

Elsevier Masson France EM|consulte www.em-consulte.com/en

REVIEW

Operating room hygiene: Clinical practice recommendations

D. Moszkowicz[a], C. Hobeika[b], M. Collard[c], M. Bruzzi[d], N. Beghdadi[e], J. Catry[f], E. Duchalais[g], G. Manceau[b], T. Voron[h], Z. Lakkis[i], M.-A. Allard[e], F. Cauchy[c], L. Maggiori[j,*], for the Société Française de Chirurgie Digestive, Association de Chirurgie Hépato-Bilio-Pancréatique et Transplantation

[a] *Service de chirurgie digestive, oncologique et métabolique, université Versailles Saint-Quentin en Yvelines, hôpital Ambroise-Paré, Assistance publique—hôpitaux de Paris (AP—HP), 92100 Boulogne-Billancourt, France*
[b] *Service de chirurgie digestive, hépato-bilio-pancréatique et transplantation, université Paris 6, hôpital Pitié-Salpétrière, Assistance publique—hôpitaux de Paris (AP—HP), 75013 Paris, France*
[c] *Service de chirurgie hépato-bilio-pancréatique et transplantation hépatique, université Paris 7, hôpital Beaujon, Assistance publique—hôpitaux de Paris (AP—HP), 92110 Clichy, France*
[d] *Service de chirurgie digestive, université Paris 5, hôpital européen Georges Pompidou, Assistance publique—hôpitaux de Paris (AP—HP), 75015 Paris, France*
[e] *Centre hépatobiliaire, université Paris 11, hôpital Paul Brousse, Assistance publique—hôpitaux de Paris (AP—HP), 94800 Villejuif, France*
[f] *Service de chirurgie générale, digestive et endocrinienne, université Paris 7, hôpital Saint-Louis, Assistance publique—hôpitaux de Paris (AP—HP), 75010 Paris, France*
[g] *Service de chirurgie digestive et endocrinienne, université de Nantes, CHU de Nantes, 44093 Nantes, France*
[h] *Service de chirurgie générale et digestive, université Paris 6, hôpital Saint-Antoine, Assistance publique—hôpitaux de Paris (AP—HP), 75012 Paris, France*
[i] *Service de chirurgie viscérale, digestive et cancérologique, université de Franche-Comté, CHRU de Besançon, 25000 Besançon, France*
[j] *Service de chirurgie colorectale, pôle des maladies de l'appareil digestif, université Paris VII (Denis Diderot), hôpital Beaujon, Assistance publique—hôpitaux de Paris (AP—HP), 100, boulevard du Général Leclerc, 92110 Clichy, France*

Available online 23 August 2019

KEYWORDS
Clinical practice recommendations;
Société française de

Summary
Introduction: The French Society of Gastro-Intestinal Surgery (*Société Française de Chirurgie Digestive*) and the Association of hepato-bilio-pancreatic and transplantation surgery (*Association de Chirurgie Hépato-Bilio-Pancréatique et Transplantation*) requested that clinical practice recommendations be established with regard to operating room hygiene.

* Corresponding author.
E-mail address: leon.maggiori@aphp.fr (L. Maggiori).

https://doi.org/10.1016/j.jviscsurg.2019.07.010

chirurgie digestive; *Association de chirurgie hépato-bilio-pancréatique et transplantation*; Operating room hygiene

Methods: The literature was analyzed according to the High Authority of Health (*Haute Autorité de santé* [HAS]) methodology and after consultation of the Cochrane and Medline databases. Pertinent references were selected, and supplementary references were hand-picked from the reference lists. Only English or French language papers were retained. The recommendations of learned societies and the World Health Organization were also considered.
Results: Recommendations were proposed with regard to pre-operative patient preparation, skin preparation, draping, wound edge protectors, surgeon hygiene, wound closure, and operating room environment.
Conclusion: These clinical practice recommendations should guide and improve the daily practice of gastro-intestinal surgeons.

Methodology

The literature was analyzed according to the methodology of the High Authority of Health (*Haute Autorité de santé*) after consultation of the Cochrane and Medline databases in April 2018. Pertinent references were selected, and supplementary references were hand-picked from the reference lists. Only English or French language papers were retained. The recommendations of learned societies and the World Health Organization were also considered.

Recommendations were proposed based on the analysis of the literature by the working group. According to the level of evidence, recommendations were graded and ranked, A, B and C, according to the following:

- grade A: scientific proof with high level of evidence (high-powered randomized trial, meta-analysis of randomized studies, decision analysis based on well-conducted studies);
- grade B: scientific presumption, provided by intermediate level of evidence (low-powered randomized trials, well-conducted non-randomized comparative studies, cohort studies);
- grade C: founded on low level of evidence (case-controlled studies, comparative studies with serious biases, retrospective studies, case series, descriptive epidemiologic studies);
- expert agreement: if there were no satisfactory studies in the literature, the recommendations relied on professional agreement between the members of the working and reading groups.

Pre-operative preparation

Pre-operative showering

What type of soap should be used for pre-operative showering?

The latest Cochrane review on this topic was published in 2015 [1]. This review included seven randomized clinical trials (RCT) with a total of 10,157 patients. The antiseptic solution used in all these trials was 4% chlorhexidine gluconate (CHX, Hibiscrub®). Overall, showering or bathing with CHX did not decrease the surgical site infection (SSI) rate statistically significantly compared to placebo (9.1% vs. 10.0%; relative risk [RR]: 0.91; [0.80—1.04]). Likewise, there was no statistically significant difference between CHX and bar soap (10.9% vs. 13.6%; RR = 1.02; [0.57—1.84]) or CHX without showering (3.5% vs. 5.6%; RR: 0.82 [0.26—2.62]). Another more recent meta-analysis involving only « clean » surgery could find no statistically significant difference between CHX and placebo (RR: 0.91; [0.76—1.09]) or between CHX and non-antiseptic soap (RR: 1.06; [0.68—1.66]) [2].

Synthesis and recommendations

A pre-operative shower or bath is recommended (expert agreement). However, no specific type of soap (antiseptic or not) has been shown to be superior and therefore any type of soap can be used (grade B).

Pre-operative shower: how many and when?

A 2008 RCT suggested that the concentration of CHX on the skin was statistically significantly lower on the skin of patients who showered only the evening before compared to the morning of the operation and those who had both a shower the evening before and the morning of surgery [3]. Conversely, there was no statistically significant difference between the patients taking a shower only the morning of surgery and those who showered both the evening before and the morning of surgery [3]. Another RCT compared the outcomes of two or three pre-operative showers with 4% CHX and found that the concentrations were statistically significantly higher when two successive applications were separated by one to two minutes compared to no interval between the showers [4]. However, the clinical impact in terms of SSI between these two strategies has never been evaluated [5].

Synthesis and recommendations

The recommendation is for patients to take at least one pre-operative shower (grade B). Two applications of soap (separated by at least one minute interval) are recommended during the shower (grade B).

Should the patient shampoo?

No specific study on this topic could be found in the literature.

Synthesis and recommendations

No recommendation with regard to shampooing during the pre-operative shower can be made.

Can CHX-impregnated cloths represent an alternative to a pre-operative shower?

No rinsing is necessary after washing with single-use 2% CHX-impregnated cloths. In a prospective cohort study comparing the use of these impregnated cloths vs. a shower with antiseptic soap, the 30-day SSI rate was statistically significantly lower in the experimental group compared to the control group (2.1% vs. 6.3%, $P = 0.01$), but the two groups were not strictly comparable, as there were more emergency operations in the control group (23% vs. 30%, $P = 0.04$), lessening somewhat the value of results [6].

Synthesis and recommendations

No formal recommendation can be made concerning the use of antiseptic cloth as an alternative or complement to pre-operative showering (grade C).

Value and modalities of hair removal

Results of pre-operative hair removal on infective complications

For the study period under scrutiny, six randomized or quasi-randomized and one well-conducted comparative study comparing pre-operative hair removal to no hair removal were found. However, only one study included patients in gastro-intestinal surgery [7]. Eighty patients were divided randomly into two groups, 40 patients each: this study found that the postoperative SSI rate was exactly the same (7.5%) in patients undergoing hair removal or not. Several studies have confirmed the absence of any benefit of hair shaving on the incidence of SSI and there even seems to be a tendency for more SSI in the hair removal group, as also suggested by four meta-analyses. Tanner et al. published the first Cochrane review in 2006, with an update in 2011 [8]. In this meta-analysis, studies referring to body hair removal were evaluated separately from those involving scalp hair removal. With regard to body hair removal, three studies were included. The meta-analysis found that morbidity was higher in the hair removal group (9.5% vs. 5.8%) but the relative risk (RR) was not statistically significant (1.65 [0.85—3.19]).

Synthesis and recommendations

Pre-operative hair removal has not been shown to be superior to no hair removal in terms of surgical site infection. Hair removal is therefore not recommended (grade A).

Skin preparation

Value and modalities of skin cleansing before application of antiseptic solutions

The value of skin scrub before application of an antiseptic solution on the reduction of SSI has been evaluated in four small sample sized RCT, three of which were included in a recent meta-analysis [9]. This meta-analysis showed that the relative risk of SSI after scrub and antiseptic solution application compared to scrub alone was not statistically significant (RR: 1.08 [0.57—2.03]) [9]. When the bibliographic search was widened to studies that used reduction of the bacteriologic count as the main outcome criteria, similar to the methodology in the meta-analysis [9], there was no statistically significant effect on the relative risk of positive cultures between scrub and antisepsis alone (RR: 0.90 [0.72—1.14]) [9]. Of note, however, the small sample size of the available studies limits the interpretation of these inconclusive results.

Synthesis and recommendations

Skin scrub before application of antiseptic solution is probably useless in patients whose skin is not dirty (pre-operative shower), but the small sample size of the available studies does not allow to come to any formal recommendation (grade B). Nevertheless, in patients who do not shower, skin cleaning before antiseptic application is recommended (expert agreements).

Value and modalities of skin prep before the incision

In all, 18 RCT and five meta-analyses [10—14] comparing various antiseptic solutions (CHX and povidone iodine [PVI]) have been published. All these meta-analyses concluded that CHX was superior to PVI [10—14]. One meta-analysis showed that an alcoholic antiseptic solution was superior to an aqueous solution in the reduction of the SSI rate (Odds-ratio [OR]: 0.60 [0.45—0.78]) [15]. More specifically, the reduction of SSI was statistically significantly better after use of an alcoholic CHX solution compared to aqueous PVI (OR: 0.65 [0.47—0.90]) but also compared to alcoholic PVI (OR: 0.58 [0.42—0.80]) [15]. These results were confirmed in a 2015 Cochrane meta-analysis that suggested that alcoholic CHX was superior to PVI in limiting the risk of SSI [16]. Finally, no RCT has yet evaluated the value of two skin preps compared to one.

Synthesis and recommendations

Alcoholic chlorexidine solution is recommended over povidone iodine (grade B). Before application of an alcoholic antiseptic solution, it is important to check that the skin does not have any break, and to use an aqueous solution (povidone iodine) when necessary (expert agreement). Before draping, one should wait for the antiseptic solution to dry (expert agreement).

Surgical draping and abdominal wall edge protectors

Choice of sterile drapes

A 2016 World Health Organization meta-analysis, including five studies comparing single-use non-woven to reusable woven drapes, did not show any statistically significant difference in the risk of SSI between the two groups [15]. Conversely, a systematic review of six studies on surgical drapes and gowns showed substantial benefits of reusable material (vs. disposable) in terms of natural resource energy sustainability (200—300%), water (250—330%), carbon footprint (200—300%), volatile organics and solid wastes (750%) [17]. The available medico-economic studies, however, are old, heterogeneous and originate from various countries. Finally, there seems to be an advantage to disposable material in terms of costs, and the differences observed are probably related to variations in local contractual negotiations with the subcontractors employed for maintenance of reusable material [17].

Synthesis and recommendations

The preferential use of disposable non-woven or reusable woven drapes cannot be recommended (grade B). Local financial, organizational and ecological constraints must be considered in the choice of textiles used.

Value of plastic adhesive drapes

Several studies have shown that the prevalence and degree of intra-operative bacterial contamination was not different between surgeries that used non-impregnated adhesive drapes or not [18]. Conversely, the use of an iodophor-impregnated plastic drape was found to decrease the prevalence of inter-operative contamination of the abdominal wall in patients undergoing clean and clean-contaminated surgery compared to patients without the adhesive protection sheets [19]. However, these protective drapes have been deceiving in the prevention of SSI. Several RCTs have evaluated the efficacy of non-impregnated adhesive drapes (5 trials) [20] or impregnated with antiseptic agents (2 trials) [20] after abdominal and orthopedic surgery or for Cesarean sections. These RCTs did not find any benefit in terms of SSI or duration of hospital stay, irrespective of the type of surgery (clean, clean-contaminated, or contaminated) [20]. These results were confirmed by a recent meta-analysis that suggested that SSI was statistically significantly higher when non-impregnated protective drapes were used (OR = 1.23 [1.02—1.48]; $P = 0.03$) [20]. Thus, both the WHO and the Center for Disease Control and Prevention (CDC) recommend against the use of adhesive drapes [15]. Lastly, the use of these drapes can be associated with undesirable effects such as PVI-related contact dermatitis or abdominal distension, a disadvantage in laparoscopic surgery.

Synthesis and recommendations

The use of adhesive drapes is not recommended for skin edge protection (grade B).

Value and choice of wound protectors

The value of wound protectors has been evaluated in eight RCTs (included in three meta-analyses [21—23]), suggesting a benefit in their use in terms of prevention of SSI. One of these meta-analyses [21], including only patients undergoing appendectomy, showed that this benefit was more important in contaminated surgery (RR = 0.44 [0.21—0.90]). The meta-analysis by Edwards et al., confirmed the benefit of wound protectors in the prevention of SSI (RR = 0.55; [0.31—0.98]; $P = 0.04$), with a non-significant tendency toward a better protection when the protector had two rings (RR = 0.31; [0.14—0.67]; $P = 0.003$) compared to wound protectors with one ring (RR = 0.83; [0.38—1.83]; $P = 0.64$) [22]. Therefore, the WHO recommends the use of these wound protectors in clean-contaminated, contaminated or dirty surgery [15].

Synthesis and recommendations

The benefit of wound protectors in the prevention of SSI has been shown, with a tendency toward better protection with double ring devices. The use of wound protection is recommended for dirty, contaminated or clean-contaminated surgery (grade A).

Surgeon hygiene

Hand scrub modalities

In 2017, a randomized clinical trial comparing hand washing with CHX-based antiseptic soap, PVI-based antiseptic soap and disinfection with hydro-alcoholic (SHA) solution showed that CHX and SHA were associated with a statistically significant decrease in skin bacterial counts compared to PVI [24]. The study concluded that SHA was the preferred technique with regard to surgeon comfort. Effectively, SHA was shown to be better in terms of tolerance, compliance and costs, compared to the antiseptic soaps. Nonetheless, no study has shown that SHA was superior to antiseptic soaps with respect to SSI rates. A 2008 Cochrane revue, updated in 2016, concluded that there was no formal evidence that one hand scrub procedure was better than any other [25]. Based on these results, the WHO proposed to use either an antiseptic foam solution or the SHA rub [15].

Synthesis and recommendations

It is recommended to use a hydro-alcoholic solution for hand scrub because, even if its use is not associated with decreased SSI compared to the other procedures because it is associated with better skin tolerance, surgeon compliance, and lower costs (grade C).

Modalities of use of sterile gloves

Utility of double gloving

Theoretically, double gloving should reduce the risk of SSI while also reducing the operating team's risk of accidental contact with blood or body fluids, particularly since glove perforations go visually unnoticed in most cases. A Cochrane meta-analysis of RCTs that included patients undergoing a wide variety of different surgeries, however, showed that double gloving did not modify the risk of SSI compared to wearing only one pair of gloves [26]. Conversely, there was a statistically significant reduction in the risk of inner glove perforation when two sets of gloves were worn [27]. However, surgeons commonly feel that double gloving reduces surgeon dexterity and precision of surgical gestures by reduction of tactile perception of instruments and tissues. Notwithstanding, the only study on this specific topic did not show any statistically significant difference in duration of operation in ENT surgery according to whether one or two pairs of gloves were used [28].

Frequency of change of gloves

There is no study that determines the minimal interval of time after which a change of gloves is recommended. The question of the value of changing gloves before manipulation of implantable material has never been studied specifically in gastro-intestinal surgery.

Antiseptic gloves

The use of antiseptic-impregnated gloves decreases bacterial passage through the glove compared with standard gloves but no clinical benefit has ever been reported: one 2014 Cochrane review concluded that there was no formal evidence in favor of the use of special gloves [29].

Synthesis and recommendations

It is recommended to wear two sets of gloves for the prevention of adverse events (expert agreement) even though there is no formal evidence of reduction in the risk of SSI (grade C). Routine use of antiseptic-impregnated gloves cannot be recommended (grade C).

Choice of operating room attire

There are no studies that have investigated the attire of patients when they arrive in the operating room or the impact that this would have on the SSI rate. Likewise, no studies have looked at the surgeon's clothing beneath the operating room gowns, whether reusable or single-use.

Synthesis and recommendations

In the absence of published studies, the working group recommends that all operating personnel wear either reusable or single-use scrub attire that should be changed between operations when soiled as well as at the end of each working day (expert agreement).

Choice of operating room attire

Type of gown

Only one randomized study has been conducted (in cardiac surgery) that evaluated the value of single-use (vs. reusable) draping and gowns in 505 patients [30]. No statistically significant difference was found in the SSI rate [30]. More recently, another RCT reported a decrease in bacterial contamination when non-woven paper gowns were compared to textile gowns [31]. In case of bleeding during surgery, « reinforced » gowns, with an inner impermeable layer of fabric, led to decreased risk of forearm contamination [32]. However, the value of such material in the reduction of SSI was not studied.

Special attire

Special attire such as protective spacesuits are used in surgical specialties that require maximal precautions (e.g. orthopedic implant surgery). However, no similar studies have been conducted in general or gastro-intestinal surgery.

Change of gowns

Some teams change gowns between the septic and non-septic phases of an operation, although there are no data published in the literature on this topic.

Synthesis and recommendations

The working group recommends the use of disposable non-woven gowns, to be discarded after each utilization (grade C). « Reinforced » gowns should be used for high risk (hemorrhagic) operations to prevent surgeon contamination from blood or body fluids (grade C). The size of the gown should be adapted to the morphology of the user and cover the legs below the knees, including when the user is sitting (grade C).

Value of protective eyewear

Protective eyewear is recommended in the circular nº DGS/DH/98/249 of April 20 1998 relative to the prevention of transmission of infectious agents *via* blood or biological fluids during procedures in health care institutions. Mansour et al. created an experimental model in which they compared the efficacy of different types of protective eyewear and showed an advantage for single-use plastic protective glasses, leading to a significant reduction in conjunctival contamination compared to the controls [33]. The superiority of single-use glasses was confirmed in another study that reported a 37.7% and 94.9% microbial contamination rate for single-use and reusable glasses, respectively [34]. No study, however, has shown any protective role of eyewear in the onset of SSI.

Synthesis and recommendations

The working group recommends single-use protective eyewear to prevent exposure to blood or body fluids (grade C).

Value and choice of surgical headdress

Even though most directives recommend wearing a surgical hood covering beard, hair and ears, thus limiting the amount of skin surface exposed, only two studies have specifically investigated this topic: they were unable to show any statistically significant difference in the SSI rate between surgeons who wore a washable cap or a single-use mobcap [35,36].

Synthesis and recommendations

It is recommended to wear a surgical headdress that covers the hair of the scalp as well as any facial hair growth (beard), as necessary (expert agreement). No preference can be recommended for the type of headdress (mobcap, surgical cap or hood; single-use or washable) (grade C).

Value of surgical masks

The first RCT on this topic was performed in 1984 on a very small sample in gynecology and was discontinued because of the onset of three postoperative infections in the group where no surgical mask was worn, whereas no infection was noted in the group where masks were used [37]. In 1991, Tunevall et al. reported the results of a RCT including 3088 patients that was unable to find any statistically significant difference in the wound infection rate according to whether surgeons wore a surgical mask or not (4.7% vs. 3.5%) [38]. In 2002, a RCT in ophthalmology including 221 patients compared the microbial contamination rate on agar placed near the patient's head during cataract surgery performed by surgeons with or without a surgical mask [39]. A statistically significant reduction in microbial contamination of the agar culture was found ($P < 0.001$), but without any clinically significant effect as there were no patients with postoperative infection in either group. With regard to operating room personnel during the operation, one study was unable to find any statistically significant difference in the reduction of SSI when a mask was worn [40]. A Cochrane review concluded that there was no proof that wearing a surgical mask reduced the SSI rate [41].

Synthesis and recommendations

Wearing a surgical mask is recommended, as it limits the transmission of micro-organisms harbored in the oropharynx and nose to the operative wound, but without any clinical impact on the risk of SSI (grade B).

Value and choice of overshoes and clogs in the operating room

There are no studies that have investigated the value of wearing clogs in the operative room to reduce the risk of SSI. With regard to overshoes, two clinical studies were unable to show any difference in the reduction of bacterial flora on the operating room floor, but the clinical impact in terms of SSI was not evaluated [42,43].

Synthesis and recommendations

No studies have shown any value of wearing clogs or shoe covers in the operating room. The working group recommends nonetheless wearing clogs that remain in the operating theater and are washed every day, or else disposable overshoes for every surgical intervention (expert agreement).

Wound closure

Value and modalities of complementary wound irrigation before closure

Irrigation of the surgical wound with physiological saline before closure has not been shown to decrease the risk of SSI [44]. Conversely, one other study comparing the use of physiological saline to PVI found a statistically significantly superiority of PVI in terms of SSI, irrespective of the degree of contamination according to the Altemeier classification [45]. Direct contact with aqueous PVI has been said to alter mesothelial cell and neutrophil white cell function and is associated with an increased risk of SSI, theoretically increased by a locally induced immunosuppressive phenomenon. However, these in vitro results have not been confirmed clinically in vivo. Effectively, only one study has shown a very moderate deleterious effect after colorectal surgery where the SSI rate rose from 12.8% to 17.7% after a second PVI wound irrigation ($P = 0.04$) [46]. Aside from this one study, most of the other clinical studies have shown a small but statistically significant decrease in SSI and these results were confirmed by one meta-analysis [47]. These data concerned the use of aqueous PVI; there are no studies at present that have compared aqueous CHX to PVI for incisional wound irrigation before wound closure.

Synthesis and recommendations

A second irrigation with an antiseptic solution is recommended before wound closure (grade A).

Value and modalities of complementary draping before wound closure

Several studies have evaluated the efficacy of wound closure protocols in the prevention of SSI and among the numerous preventive measures is the change of operative drapes before wound closure. These protocols have been shown to be efficient as the SSI rate was thus lowered by 10 to 15% whether for pancreatic [48] or colorectal surgery [49]. However, as the effect of any individual measure has never been analyzed alone it is not possible to evaluate the impact a change of draping in the prevention of SSI.

Synthesis and recommendations

Changing surgical draping before wound closure is recommended, even if this gesture has never been specifically evaluated (grade A). Complementary draping should cover the first and not replace it in order to prevent any contamination during the change (expert agreement).

Value and modalities of changing instruments before closure

Changing surgical instruments before closure is one of the numerous measures in operating room protocols meant to prevent SSI. With the exception of one, all the studies evaluating these prevention protocols have shown that this measure was effective [48—50]. The only study that was unable to show any benefit of such a protocol [51] was small compared to the others, and included heterogeneous procedures (gynecologic and urological) for which the risk of SSI was low.

Synthesis and recommendations

Changing instruments before wound closure is recommended in gastro-intestinal surgery, even though the value of such a change has never been specifically evaluated (grade A).

Use of Triclosan-coated sutures

Triclosan (5-chloro-2-[2,4-dichlorophenoxy] phenol) is a large spectrum antibacterial and antifungal biocide that acts by interfering with microbial lipidic synthesis and limits bacterial proliferation and colonization. Use of Triclosan-coated sutures could partially destroy the bacteria most often responsible for SSI on the surface of sutures. Eight meta-analyses have been published on this topic between 2012 and 2016. The most recent of these grouped 21 randomized trials with a total of 6462 patients undergoing various operations in gastro-intestinal, cardiac and ENT surgery [52]. In this study, the use of Triclosan dipped sutures was associated with a statistically significant decrease in SSI, from 138/1000 to 99/1000. These good results, however, have to be confronted with those of two well-conducted multicenter randomized trials (included in the meta-analysis [52]) and that on one side, specifically involved patients undergoing abdominal surgery and on the other, analyzed the effect of Triclosan dipped predefined suture material (Polydioxanone and Polyglactin 910). In both of these studies, use of Triclosan was not associated with any statistically significant decrease in the SSI rate [52].

Synthesis and recommendations

Triclosan dipped sutures seem to be associated with a statistically significant diminution in SSI in various surgical specialties but not in gastro-intestinal surgery, and therefore cannot be routinely recommended (grade A).

Operating room environment

Modalities of operating room cleaning

Operating room cleaning recommendations have been published by the South-West France Committee for the Fight against Noscomial Infections (*Comité de coordination de lutte contre les infections nosocomiales* [CLIN]) [53]. These measures are based on expert opinion more than on truly

scientific arguments, considering the small number of studies available. These include: hand hygiene (hydro-alcoholic rub) before and after each bio-cleaning, wiping all surfaces (operating table, head, arm and leg rests, lighting and anesthesiology equipment) with a detergent and disinfection solution, performed in one stroke, from clean to dirty, from up to down. Particular attention should be paid to cleaning keyboards, video towers, and anesthesiology equipment. The floor should be mopped or treated with high pressure steam cleaning techniques (shown to be effective for detersion and disinfection of operating room floors [54]). The products that can be used are chosen from those with proven complete antibacterial and antifungal activity [55].

Contaminated surfaces are a potential source of contamination when sediment particles become suspended in the air by the movement of personnel in the operating room. The French Society of Hospital Hygiene (*Société française d'hygiène hospitalière* [SF2H]) recommends a minimal interval of time for elimination of more than 90% of the particles of at least 0.5 μ present in air suspension [56]. The time necessary for particle elimination is less than or equal to 10 minutes for operating rooms where the level of operative site infection (ISO) risk is 7, which is usual for particle contamination; this is compatible with activities in gastro-intestinal surgery and transplantation according to the recommendations of the central CLIN of Paris Hospitals. Moreover, as bio-cleaning is a source of particles, the time necessary for the procedure cannot be counted within the interval of time between two operations.

There is no formal proof that disinfection of surfaces (if they are not macroscopically dirty) after each operation reduces the risk of infection. According to the experts of the SF2H, as long as the surfaces do not enter into direct contact with the operative site, the risk of infective transmission is low [56]. Therefore, the experts strongly agreed to recommend that all operating room surfaces be cleaned and disinfected after every operation, including mopping of the floors. For operations that are associated with soiling, mopping must be completed by manual lavage with a detergent and disinfecting product. For patients infected with or carriers of multi-resistant bacteria or for contaminated (Altemeier Class III) or dirty (Altemeier Class IV) [57] surgeries, additional specific measures, such as airway disinfection, are not called for [56].

Finally, the regional CLIN stipulates that all operating room surfaces be disinfected and that the floor be cleaned with a detergent/disinfectant solution after every operative session.

Synthesis and recommendations

Our group did not make any particular modification of the recommendations proposed by the regional CLIN (expert agreement).

Management of patients with latex allergy

The mainstay of management is elimination of latex allergens. The measures that reduce the risk of contact with latex allergens intervene at several levels:

- direct contact: absence of contact between the patient and latex is assured by use of latex-free material, the cornerstone of secondary prevention of latex allergy. This means that all carts in the operating room be latex-free, and that there is an evening-before check that all equipment that will be used the next day is latex-free;
- inhalation: to limit the quantity of aero-allergens that are dispersed when the surgeons take off their gloves, and therefore the risk of allergic reaction, it seems preferable to schedule the high-risk patient as the first case. If this is not possible, a delay of at least one hour between operations is necessary to resolve the problem of air-suspended particles. Likewise, the bio-cleaning team should wear latex-free gloves;
- organization: several secondary prevention hospital protocols have been published [58]. A severe anaphylactic reaction to latex during a urologic operation was reported recently. This accident is full of information in several aspects.

Drug prophylaxis (antihistaminiic and/or steroids) has not been shown to be effective [59]. Certain authors have even suggested that some forerunner signs of allergy could be retarded and lead to delay in diagnosis.

Synthesis and recommendations in case of recognized allergy to latex

Using latex material is strictly contra-indicated. Only latex-free material should be used (grade A). The experts recommend setting up a cart with latex-free material only. The cart must be complete, and its placement known to all health care personnel (grade A). Airborne allergens are least for patients who are first on the operation schedule (grade A). In case of organizational problems, latex-free material must be used for the entire operation program. Patients with recognized latex allergy should wear an identification bracelet labelled « latex allergy » and this should be clearly indicated in the patient record (grade C). Drug prophylaxis for patients with latex allergy is not recommended (grade C).

Management of patients who are multi-drug resistant bacteria (MDRB) carriers

The French Society of Hospital Hygiene (*Société française d'hygiène hospitalière*; SFHH) published recommendations on this topic in 2009 [60]. These recommendations recall the characteristics of multi-drug resistant bacteria (MDRB): commensal bacteria, multi-drug resistance to regularly-used antibiotics, hand-borne transmission mechanism overriding the risk of mutation/adaptation in the presence of antibiotics, endemic in all hospitals in France and emergent highly resistant bacteria (eMDRB) (commensal intestinal bacteria resistant to vancomycin or imipenem).

The recommendations of the SF2H are not to schedule a patient with MDRB at the end of the daily operative list as long as all precautions have been taken to avoid any inopportune contact and that adequate bio-cleaning can be performed [61]. This recommendation is founded on the fact that if all precautions are correctly taken, the risk of cross-over transmission in the operating room are nearly nil, which means that no specific measures are necessary specifically for MDRB carriers.

The potential severity in case of infection and the risk of diffusion of eMDRB when the necessary precautions are not taken, have led the High Committee of Public Health [62] to specifically recommend that the index patient be isolated and managed by dedicated personnel, and that other patients who potentially could have been in contact with the index patient, be confined to the same health care area.

The efficacy of these measures has been confirmed several times.

Synthesis and recommendations

The recommendation is that it is not necessary to modify the operative scheduling order of patients with MDRB as long as all precautions have been taken to avoid any inopportune contact and that appropriate cleaning is undertaken between two operations (expert agreement). Conversely patients with eMDRB should be scheduled last on the operation schedule, and the transfer to the operating theater should be managed by dedicated personnel (grade C).

Other measures in the operating room

Noise in the operating theater

The negative effect of noise in the operating theater has been shown extensively [63]: noise decreases the capacity of concentration, short-term memory, modifies the quality of communication, decreases overall professional performance and can compromise patient safety. Moreover, exposure to excessive noise has long-term consequences such as loss of acoustic acuity, and increased risk of cardiovascular disease (hypertension, premature death, myocardial infarction).

Synthesis and recommendations

It is strongly recommended to limit the volume of sound in the operating room, and in particular, to avoid any conversations that do not have any direct relation with health care (grade B).

Music in the operating room

One randomized study compared execution scores for various surgical tasks performed on a laparoscopic simulator by novice surgeons under three different settings: no music, deactivating (relaxing) music or activating music [64]. The highest scores were obtained when the surgeons listened to deactivating or no music while activating or dynamic music decreased the technical performances. Of note, the authors also observed that tasks were best performed and more rapidly when the music was judged to be ''pleasant''. The same type of study was performed with other surgeons, experts in laparoscopic surgery, and suggested that classical music had a positive effect on the technical precision of surgeons [65]. Lastly, classical music has been found to enhance laparoscopic learning [66].

Synthesis and recommendations

In accordance with the preceding recommendation concerning auditive volume in the operating room, routinely listening to music cannot be recommended (grade A). Listening to music is acceptable but only if chosen by the operator, and with the agreement of the rest of the team; music should be ''non-activating'' and low volume (grade B).

Impact of operating room traffic and opening of doors during surgery

The only RCT on this topic was published in 2016 and evaluated the effect of restricted circulation of personnel in the operating room (no observers or students, non-use of the main door during the operation), compared to ''free circulation'' on the risk of SSI after neurosurgical operations [67]. There was no decrease of the risk of infection in the group observing ''traffic restrictions''.

Synthesis and recommendations

No restrictions can be recommended with regard to the number of persons in the operating room (grade A).

Impact of the presence of students

Students need to be exposed to the operating room during their training. Most physicians, operating room personnel and even patients recognize the pedagogical value of a surgical clerkship rotation during training including observing what goes on in an operating room. It is difficult, however, to evaluate how the presence of medical student observers influences the progress of a surgical operation and outcomes, mainly because there are so many confounding factors. Moreover, several studies have shown that the attitude of surgeons towards students had a determining role in their choice of becoming surgeons or not and that this influence was often under-estimated by the surgeons themselves. While actual passing out (loss of consciousness) is a relatively rare occurrence, one Canadian study showed that pre-syncopal symptoms or faintness were experienced by 42% of students [68]. These malaises are important to consider because they can lead to falls, that could disturb the operation and affect the impression students have of the operating room and surgery. Lastly, there are no data relative to the impact of the presence of students in the operating room on the risk of SSI or the duration of operation.

Synthesis and recommendations

Exposure to the operating room should be mandatory during training of medical students (expert agreement). Surgeons should be aware that their behavior in the operating room can influence students (grade C). Routine explanation of premonitory signs, adequate eating and hydration before exposure are preventive measures to avoid malaise (grade C).

Acknowledgments

The two learned societies, SFCD and ACHBT wish to thank the members of the working and reading teams that participated in these recommendations:

- Nathalie Breton, service de chirurgie digestive et hépato-bilio-pancréatique, CHU de Pitié-Salpêtrière, Assistance publique—hôpitaux de Paris, France;
- Christine Gourbeyre-Ceretta: cadre de santé, équipe opérationnelle d'hygiène, CHU de Pitié-Salpêtrière, Assistance publique—hôpitaux de Paris, France;
- Najiby Kassis Chikhani, biologie médicale et hygiène hospitalière, hôpital européen Georges Pompidou, Assistance publique—hôpitaux de Paris (AP—HP), France;
- Emilia Ragot, service de chirurgie digestive, hôpital européen Georges Pompidou, Assistance publique—hôpitaux de Paris (AP—HP), France;
- Claire Falcou, service de chirurgie digestive, hôpital européen Georges Pompidou, Assistance publique—hôpitaux de Paris (AP—HP), France;
- Emilie Duchalais, service de chirurgie digestive, CHU de Nantes, France;
- Martin Bertrand, service de chirurgie digestive, Nimes, France;
- Julie Fercoq, institut de formation en soins infirmiers, Paris, France;

- Jean Ralph Zahar, laboratoire de bactériologie-virologie-hygiène, AP—HP, Paris, France;
- Pascale Bailly, réseau Franc-Comtois de lutte contre les infections nosocomiales, CHRU de Besançon, France;
- Allison Muller, pharmacien, réseau Franc-Comtois de lutte contre les infections nosocomiales, CHRU de Besançon, France;
- Amélie Varin, biohygiéniste, réseau Franc-Comtois de lutte contre les infections nosocomiales, CHRU de Besançon, France;
- Sophie Mouillet, cadre IBODE, CHRU de Besançon, France;
- Céleste Roxo-Clemente, cadre IBODE, CHRU de Besançon, France;
- Xavier Bertrand, pharmacien, réseau Franc-Comtois de lutte contre les infections nosocomiales, CHRU de Besançon, France
- Benoit Pilmis, service de maladies infectieuses et tropicales, université Paris V-Descartes, hôpital Necker enfant-malades, Assistance publique—hôpitaux de Paris, Paris, France;
- Anne Sophie Schneck, service de chirurgie hépato-bilio-pancréatique et transplantation hépatique, hôpital Beaujon, université Paris VII-Diderot, Assistance publique—hôpitaux de Paris, France;
- Raquel Perez, service de chirurgie hépato-bilio-pancréatique et transplantation hépatique, hôpital Beaujon, Assistance publique—hôpitaux de Paris, Paris, France;
- Patricia Baune, pharmacien-biologiste et hygiéniste, hôpital Paul Brousse, 94800 Villejuif, France;
- Nicolas Golse, centre hépatobiliaire, hôpital Paul Brousse, 94800 Villejuif, France.

Disclosure of interest

The authors declare that they have no competing interest.

References

[1] Webster J, Osborne S. Preoperative bathing or showering with skin antiseptics to prevent surgical site infection. Cochrane Database Syst Rev 2015 [CD004985].

[2] Franco LM, de C, Cota GF, Pinto TS, Ercole FF. Preoperative bathing of the surgical site with chlorhexidine for infection prevention: Systematic review with meta-analysis. Am J Infect Control 2017;45:343—9.

[3] Edmiston CE, Krepel CJ, Seabrook GR, Lewis BD, Brown KR, Towne JB. Preoperative shower revisited: can high topical antiseptic levels be achieved on the skin surface before surgical admission? J Am Coll Surg 2008;207:233—9.

[4] Edmiston CE, Lee CJ, Krepel CJ, et al. Evidence for a standardized preadmission showering regimen to achieve maximal antiseptic skin surface concentrations of chlorhexidine gluconate, 4%, in surgical patients. JAMA Surg 2015;150:1027—33.

[5] Poirot K, Le Roy B, Badrikian L, Slim K. Skin preparation for abdominal surgery. J Visc Surg 2018;155:211—7.

[6] Graling PR, Vasaly FW. Effectiveness of 2% CHG cloth bathing for reducing surgical site infections. AORN J 2013;97:547—51.

[7] Rojanapirom S, Danchaivijitr S. Pre-operative shaving and wound infection in appendectomy. J Med Assoc Thail Chotmaihet Thangphaet 1992;75(2):20—3.

[8] Tanner J, Norrie P, Melen K. Preoperative hair removal to reduce surgical site infection. Cochrane Database Syst Rev 2011 [CD004122].

[9] Lefebvre A, Saliou P, Mimoz O, et al. Is surgical site scrubbing before painting of value? Review and meta-analysis of clinical studies. J Hosp Infect 2015;89:28—37.

[10] Zhang D, Wang X-C, Yang Z-X, Gan J-X, Pan J-B, Yin L-N. Preoperative chlorhexidine versus povidone-iodine antisepsis for preventing surgical site infection: a Meta-analysis and trial sequential analysis of randomized controlled trials. Int J Surg 2017;44:176—84.

[11] Privitera GP, Costa AL, Brusaferro S, et al. Skin antisepsis with chlorhexidine versus iodine for the prevention of surgical site infection: a systematic review and meta-analysis. Am J Infect Control 2017;45:180—9.

[12] Lee I, Agarwal R, Lee B, Fishman N, Umscheid C. Systematic review and cost analysis comparing use of chlorhexidine with use of iodine for preoperative skin antisepsis to prevent surgical site infection. Infect Control Hosp Epidemiol 2010:31.

[13] Dumville J, McFarlane E, Edwards P, Lipp A, Holmes A, Liu Z. Preoperative skin antiseptic for prevention of surgical wound infections after clean surgery. Cochrane Database Syst Rev 2015 [CD003949].

[14] Noorani A, Rabey N, Walsh SR, Davies RJ. Systematic review and meta-analysis of preoperative antisepsis with chlorhexidine versus povidone-iodine in clean-contaminated surgery. Br J Surg 2010;97:1614—20.

[15] Allegranzi B, Bischoff P, de Jonge S, et al. New WHO recommendations on preoperative measures for surgical site infection prevention: an evidence-based global perspective. Lancet Infect Dis 2016;16:e276—87.

[16] Dumville J, McFarlane E, Edwards P, Lipp A, Holmes A, Liu Z. Preoperative skin antiseptic for prevention of surgical wound infections after clean surgery. Cochrane Database Syst Rev 2013 [CD003949].

[17] Overcash M. A comparison of reusable and disposable perioperative textiles: sustainability state-of-the-art 2012. Anesth Analg 2012;114:1055—66.

[18] Chiu KY, Lau SK, Fung B, Ng KH, Chow SP. Plastic adhesive drapes and wound infection after hip fracture surgery. Aust N Z J Surg 1993;63:798—801.

[19] Dewan PA, Van Rij AM, Robinson RG, Skeggs GB, Fergus M. The use of an iodophor-impregnated plastic incise drape in abdominal surgery — a controlled clinical trial. Aust N Z J Surg 1987;57:859—63.

[20] Webster J, Alghamdi A. Use of plastic adhesive drapes during surgery for preventing surgical site infection. Cochrane Database Syst Rev 2015 [CD006353].

[21] Ahmed K, Connelly TM, Bashar K, Walsh SR. Are wound ring protectors effective in reducing surgical site infection post appendectomy? A systematic review and meta-analysis. Ir J Med Sci 2016;185:35—42.

[22] Edwards JP, Ho AL, Tee MC, Dixon E, Ball CG. Wound protectors reduce surgical site infection: a meta-analysis of randomized controlled trials. Ann Surg 2012;256:53—9.

[23] Gheorghe A, Calvert M, Pinkney TD, et al. Systematic review of the clinical effectiveness of wound-edge protection devices in reducing surgical site infection in patients undergoing open abdominal surgery. Ann Surg 2012;255:1017—29.

[24] Tsai J-C, Lin Y-K, Huang Y-J, et al. Antiseptic effect of conventional povidone-iodine scrub, chlorhexidine scrub, and waterless hand rub in a surgical room: a randomized controlled trial. Infect Control Hosp Epidemiol 2017;38:417—22.

[25] Tanner J, Dumville JC, Norman G, Fortnam M. Surgical hand antisepsis to reduce surgical site infection. Cochrane Database Syst Rev 2016 [CD004288].

[26] Tanner J, Parkinson H. Double gloving to reduce surgical cross-infection. Cochrane Database Syst Rev 2006 [CD003087].

[27] Makama JG, Okeme IM, Makama EJ, Ameh EA. Glove perforation rate in surgery: a randomized controlled study to evaluate the efficacy of double gloving. Surg Infect 2016;17:436—42.

[28] Hardison SA, Pyon G, Le A, Wan W, Coelho DH. The effects of double gloving on microsurgical skills. Otolaryngol Head Neck Surg 2017;157:419—23.

[29] Mischke C, Verbeek JH, Saarto A, Lavoie M-C, Pahwa M, Ijaz S. Gloves, extra gloves or special types of gloves for preventing percutaneous exposure injuries in healthcare personnel. Cochrane Database Syst Rev 2014 [CD009573].
[30] Bellchambers J, Harris JM, Cullinan P, Gaya H, Pepper JR. A prospective study of wound infection in coronary artery surgery. Eur J Cardio Thorac Surg 1999;15:45—50.
[31] Ward WG, Cooper JM, Lippert D, Kablawi RO, Neiberg RH, Shertz RJ. Glove and gown effects on intraoperative bacterial contamination. Ann Surg 2014;259:591—7.
[32] Jones DR, Harris R, Wilson K. Non-woven, disposable theatre gowns for ''high-risk'' surgery. Ann R Coll Surg Engl 1993;75:154—6.
[33] Mansour AA, Even JL, Phillips S, Halpern JL. Eye protection in orthopaedic surgery. An in vitro study of various forms of eye protection and their effectiveness. J Bone Joint Surg Am 2009;91:1050—4.
[34] Lange VR. Eyewear contamination levels in the operating room: infection risk. Am J Infect Control 2014;42:446—7.
[35] Kothari SN, Anderson MJ, Borgert AJ, Kallies KJ, Kowalski TJ. Bouffant vs skull cap and impact on surgical site infection: does operating room headwear really matter? J Am Coll Surg 2018;227:198—202.
[36] Shallwani H, Shakir HJ, Aldridge AM, Donovan MT, Levy EI, Gibbons KJ. Mandatory change from surgical skull caps to bouffant caps among operating room personnel does not reduce surgical site infections in class i surgical cases: a single-center experience with more than 15,000 patients. Neurosurgery 2018;82:548—54.
[37] Chamberlain GV, Houang E. Trial of the use of masks in the gynaecological operating theatre. Ann R Coll Surg Engl 1984;66:432—3.
[38] Tunevall TG. Postoperative wound infections and surgical face masks: a controlled study. World J Surg 1991;15:383—7 [Discussion 387—388].
[39] Alwitry A, Jackson E, Chen H, Holden R. The use of surgical facemasks during cataract surgery: is it necessary? Br J Ophthalmol 2002;86:975—7.
[40] Webster J, Croger S, Lister C, Doidge M, Terry MJ, Jones I. Use of face masks by non-scrubbed operating room staff: a randomized controlled trial. ANZ J Surg 2010;80:169—73.
[41] Vincent M, Edwards P. Disposable surgical face masks for preventing surgical wound infection in clean surgery. Cochrane Database Syst Rev 2016;4 [CD002929].
[42] Humphreys H, Marshall RJ, Ricketts VE, Russell AJ, Reeves DS. Theatre over-shoes do not reduce operating theatre floor bacterial counts. J Hosp Infect 1991;17:117—23.
[43] Duquette-Petersen L, Francis ME, Dohnalek L, Skinner R, Dudas P. The role of protective clothing in infection prevention in patients undergoing autologous bone marrow transplantation. Oncol Nurs Forum 1999;26:1319—24.
[44] Al-Ramahi M, Bata M, Sumreen I, Amr M. Saline irrigation and wound infection in abdominal gynecologic surgery. Int J Gynaecol Obstet 2006;94:33—6.
[45] Sindelar WF, Mason GR. Irrigation of subcutaneous tissue with povidone-iodine solution for prevention of surgical wound infections. Surg Gynecol Obstet 1979;148:227—31.
[46] Ortiz H, Armendariz P, Kreisler E, et al. Influence of rescrubbing before laparotomy closure on abdominal wound infection after colorectal cancer surgery: results of a multicenter randomized clinical trial. Arch Surg 2012:147.
[47] de Jonge SW, Boldingh QJJ, Solomkin JS, et al. Systematic review and meta-analysis of randomized controlled trials evaluating prophylactic intra-operative wound irrigation for the prevention of surgical site infections. Surg Infect 2017;18:508—19.
[48] Hashimoto D, Chikamoto A, Arima K, et al. Unused sterile instruments for closure prevent wound surgical site infection after pancreatic surgery. J Surg Res 2016;205:38—42.
[49] Connolly TM, Foppa C, Kazi E, Denoya PI, Bergamaschi R. Impact of a surgical site infection reduction strategy after colorectal resection. Colorectal Dis 2016;18:910—8.
[50] Keenan JE, Speicher PJ, Thacker JKM, Walter M, Kuchibhatla M, Mantyh CR. The preventive surgical site infection bundle in colorectal surgery: an effective approach to surgical site infection reduction and health care cost savings. JAMA Surg 2014;149:1045.
[51] Kwaan MR, Weight CJ, Carda SJ, et al. Abdominal closure protocol in colorectal, gynecologic oncology, and urology procedures: a randomized quality improvement trial. Am J Surg 2016;211:1077—83.
[52] de Jonge SW, Atema JJ, Solomkin JS, Boermeester MA. Meta-analysis and trial sequential analysis of triclosan-coated sutures for the prevention of surgical-site infection. Br J Surg 2017;104:e118—33.
[53] CCLIN Sud-Est. Recommandations pour l'entretien des blocs opératoires; 2006 [Available from: http://nosobase.chu-lyon.fr/recommandations/cclin_arlin/cclinSudOuest/2006_chirurgie_CCLIN.pdf].
[54] SFHH. Bulletin Nº 70 : avis sur un procédé de nettoyage et désinfection à la vapeur; 2004 [Available from: https://sf2h.net/wp-content/uploads/2004/11/SF2H_avis-vapeur-2004.pdf].
[55] SF2H. Guide pour le choix des desinfectants; 2015 [Available from: http://nosobase.chu-lyon.fr/recommandations/sfhh/2015_desinfectants_SF2H.pdf].
[56] SF2H. Recommandations : qualité de l'air au boc opératoire et autres secteurs interventionnels; 2015 [Available from: https://sf2h.net/wp-content/uploads/2015/05/SF2H_recommandations_qualite-de-l-air-au-bloc-operatoire-et-autres-secteurs-interventionnels-2015.pdf].
[57] Altemeier WA. Sepsis in surgery. Presidential address. Arch Surg 1982;117:107—12.
[58] Reines HD, Seifert PC. Patient safety: latex allergy. Surg Clin North Am 2005;85:1329—40.
[59] Setlock MA, Cotter TP, Rosner D. Latex allergy: failure of prophylaxis to prevent severe reaction. Anesth Analg 1993;76:650—2.
[60] SF2H. Actualisations des précautions standard; 2017.
[61] SFHH. Prévention de la transmission croisée : précautions complémentaires contact; 2009.
[62] Haut conseil de la santé publique. Prévention de la transmission croisée des bactéries hautement résistantes aux antibiotiques émergentes (BHRe). Prévention de la transmission croisée des bactéries hautement résistantes; 2013.
[63] Katz JD. Noise in the operating room. Anesthesiology 2014;121:984—8.
[64] Miskovic D, Rosenthal R, Zingg U, Oertli D, Metzger U, Jancke L. Randomized controlled trial investigating the effect of music on the virtual reality laparoscopic learning performance of novice surgeons. Surg Endosc Interv Tech 2008;22:2416—20.
[65] Conrad C, Konuk Y, Werner P, et al. The effect of defined auditory conditions versus mental loading on the laparoscopic motor skill performance of experts. Surg Endosc Interv Tech 2010;24:1347—52.
[66] Conrad C, Konuk Y, Werner PD, et al. A quality improvement study on avoidable stressors and countermeasures affecting surgical motor performance and learning. Ann Surg 2012;255:1190—4.
[67] Bohl MA, Clark JC, Oppenlander ME, et al. The Barrow Randomized Operating Room Traffic (BRITE) trial: an observational study on the effect of operating room traffic on infection rates. Neurosurgery 2016;63:91—5.
[68] Morzycki A, Hudson A, Williams J. Medical student presyncope and syncope in the operating room: a mixed methods analysis. J Surg Educ 2016;73:1004—13.