

Observational study on preoperative surgical field disinfection: Povidone-iodine and Chlorhexidine-alcohol

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Abstract. – BACKGROUND AND OBJECTIVES: Surgical site infection (SSI) rate is reported to range around 16%. Preoperative skin disinfection is keystone for SSI reduction. Chlorhexidine-alcohol has been reported to be more effective than Povidone-iodine (PVI). However, in many countries established habits and the inferior costs of PVI restrain the employment of chlorhexidine disinfection kits (ChlorPrep®) for the preparation of the surgical field.

MATERIALS AND METHODS: The costs of surgical field preparation in clean-contaminated surgery utilizing PVI (Betadine) and chlorhexidine alcohol and the evaluation of surgeon compliance and satisfaction, were studied by a observational study on 50 surgical operations in which surgical field was prepared with PVI checking established guidelines, and on 50 surgical operations in which chlorhexidine-alcohol (ChlorPrep) was employed. The use of auxiliary material was tabulated as well as the timing of the phases of disinfection and the surgeon's opinions.

RESULTS: The use of auxiliary material (gloves, gauzes, paper towels, surgical instruments, small swabs for umbilical cleaning) is associated with the type of disinfectant, with major use of auxiliary materials recorded in PVI disinfection. PVI disinfection does not follow stringent guidelines, in particular waiting for the disinfectant to dry. PVI guidelines are more demanding than those relative to ChlorPrep. The time necessary for the preparation of the field is significantly longer for PVI. Auxiliary material and guideline compliance must be taken into account when calculating costs; the former are direct costs (even though marginal) and the latter can determine major infective risk.

CONCLUSIONS: Chlorhexidine in kits is easier and faster to use than PVI, requires less auxiliary material and has been shown previously to reduce SSI in clean contaminated surgery.

Key Words:

Povidone-iodine, Chlorhexidine, ChlorPrep®, Betadine®, Surgical site infection, Surgical field disinfection, Skin disinfection for surgery.

Introduction

Surgical site infections (SSI) increase morbidity, mortality and financial burden of surgical operations¹. They double the cost of treatment, mainly due to an increase in length of stay. SSI represent about one fifth of all healthcare associated infections and in the most propitious reviews they never fall under a 5% incidence even in the most favourable and clean of surgical operations². Clean-contaminated operations have a SSI rate of 10%-16% in most series from USA³, and post-discharge SSI ranges around 2%⁴. In Europe no extensive studies exist but from cumulative data collection in 2004, a percentage ranging from 1.5% to 20% appears to be the case⁵.

Preoperative disinfection of skin is one of the keystones for reducing SSI⁶, and from 2010 chlorhexidine-alcohol has been suggested to be superior to the classical PVI disinfection⁷.

However, in many countries well established habits and the inferior costs of PVI (Betadine antiseptic solution) commercialized in 1 litre bottles that can be utilized for up to 10 disinfections of surgical fields, and the superior costs of chlorhexidine disinfection kits (ChlorPrep®) have prevented the adoption of chlorhexidine as the disinfectant of choice for the preparation of the surgical field.

To verify the costs of surgical field preparation in clean-contaminated surgery utilizing PVI and chlorhexidine-alcohol, we performed a double

observational study on 50 surgical operations in which surgical field was prepared with PVI, according to established guidelines, and on 50 surgical operations in which chlorhexidine-alcohol (ChloraPrep 10.5/26 mL kit) was employed.

Costs of disinfection of the surgical field must take into account also adjunctive costs over those of the disinfectants, due to the use of accessory materials and the pre-incision time interval intervening between disinfection and surgical field preparation, that may differ between the two disinfection techniques.

Moreover, we have tried to verify if the application technique of the disinfectant could influence the correct use of the product. An incorrect application of the product represents an element that can influence considerably the occurrence of an SSI.

Materials and Methods

Studied Sample

This is an observational study: the investigator observed the effect of the use of one of the two disinfectants, independently chosen by the operator, both in emergency and elective surgery. The practice in the hospital is that the surgeon prepares his own surgical field, assisted by the scrub nurse, as follows: he starts pouring the product on the skin with the aid of an imbued gauze fixed with a surgical clamp (Povidone iodine) or with the applicator (ChloraPrep) starting from the middle of the field and heading periferally; sometime he adds a small swab to clean the navel. After waiting for the field to dry almost completely, he may use some big paper towels to complete the drying of the field if he considers it necessary. In fact, the adesive surgical drapes need a completely dry skin to stick on. The above steps correspond to the recorded time items in the Data Collection Form (see after and Appendix 1).

All the surgeons stated that they had received training for the use of the products.

Data were gathered observing 100 medium and major operations performed by 27 different surgeons who were asked for permission to have a surgical resident as observer in the operating room.

The observer recorded the entire disinfection procedure of the surgical field, transcribing a set of information according to a pre-styled Data Collection form. At the end of the disinfection procedure the same observer asked the surgeon his/her opinion on the ease of use of the disinfectant and his/her approval or liking, according to a

small questionnaire included in the Data Collection form and reported in the Appendix.

Type of Disinfection

Disinfection with PVI was carried out according to the classical technique, following international guidelines for Betadine antiseptic solution commercialized in 1 litre bottles.

Disinfection with clorhexidine-alcohol was carried out with the ChloraPrep 26 mL or 10.5 mL formulation, following the instructions provided with product.

Data Collection Form

The Data Collection Form reported in the Appendix 1 includes and defines the variables collected by the observer during the preparation of the surgical field. These are objective data measured by the observer and subjective data recorded interviewing the surgeon after he or she finishes the operation.

The observer recorded the type of disinfection, the type of applicator and the quantity of utilized solution; the number of gauzes utilized for the disinfection if necessary; the number of instruments, tampons imbued, gloves used for and during the disinfection; the number of gauzes/towels used to dry the field; the application and drying time (in seconds) as well as the total time needed for disinfection (from the beginning of painting to placing of drapes). Moreover an evaluation of the degree of dirtiness of the floor was recorded.

At the end of the operation, the surgeon was asked a series of questions about the ease of use of the disinfectant, the efficacy in terms of time necessary for drying, about his satisfaction on the area covered and about the pooling/puddling of the solution. The questions aimed at understanding the approval or lack thereof by the surgeon of the employed disinfectant.

Statistical Analysis

Continuous variables were reported as mean and standard deviations; discrete variables as median and interquartile Range (IQR); categorical variables as percentages. For each type of disinfectant a descriptive analysis of the recorded variables was performed; non parametric tests were used for the comparison between the two disinfectants: the Mann-Whitney U test was used for discrete variables; the Chi-Squared test or Fisher Exact test, when appropriate, were used for studying the association between type of disinfectant and each categorical variable. Variables Application time, Drying time and Disinfection

time were analysed by means of an Analysis of Variance with disinfection type as ‘between’ factor and field dimension (Small, Medium and Large) as block factor. It was in fact supposed that the recorded times could be affected by the field dimension, a possible confounding factor for the study of the effect of type disinfectant on the recorded times. Preliminarily, a Chi-Squared test was performed to test the association between disinfection type and Field dimension.

The items of the questionnaire submitted to the surgeon foresaw answers with multiple choice: excellent, acceptable or unacceptable.

A *p* value <0.05 was considered as significant.

Results

A comparison was carried out between the two types of disinfectants analyzing the variables reported in Table I.

Comparison Between Betadine and ChloraPrep in Terms of Supplementary Material Used

For Betadine the quantity of solution prepared on the operative field was 500 mL in 6% of cases and 250 mL in the remaining 94%. For ChloraPrep, in most of the cases (88%) the 26 mL preparation was used, whereas in 12% of the cases the 10.50 mL preparation was used.

Incise drapes such as Steri-Drape™ and Ioban™ were used in 7 out of 50 cases (14%) in the Betadine group (in 5 cases Ioban™ and in 2 cases Steri-Drape™), whereas in the ChloraPrep group in 6 out of 50 cases (12%) (Ioban™ in 5 cases, Steri-Drape™ (in 1) (*p* = 1 from Chi-Squared test).

The supplementary material used for the disinfection were gauzes, surgical instruments, umbilical swabs and gloves. While in the ChloraPrep group gauzes, swabs (over those contained in the

Table I. Results: comparison between Betadine and ChloraPrep in terms of studied variables.

Variables	Betadine	ChloraPrep
Incision drapes used [%]	14%	6%
Quantity of prepared Solution [%]	250 mL – 94% 500 mL – 6%	10.5 mL – 12% 26 mL – 88%
Gauzes for disinfection		
Mean ± SD	1.76 ± 1.02	0.0 ± 0.0
Median (Interquartile Range)	2 (IQR: 1-2)	0 (IQR: 0-0)
Surgical instruments for disinfection		
Mean ± SD	1.52 ± 0.99	0.0 ± 0.0
Median (Interquartile Range)	1 (IQR: 1-2)	0 (IQR: 0-0)
Swab (out of kit)		
Mean ± SD	0.4 ± 0.67	0.0 ± 0.0
Median (Interquartile Range)	0 (IQR: 0-1)	0 (IQR: 0-0)
Extra pair of Gloves used for disinfection		
Mean ± SD	0.14 ± 0.35	0.0 ± 0.0
Median (Interquartile Range)	0 (IQR: 0-0)	0 (IQR: 0-0)
Towels/Gauzes used to dry the field		
Mean ± SD	1.62 ± 0.47	0.0 ± 0.0
Median (Interquartile Range)	2 (IQR: 1-2)	0 (IQR: 0-0)
Application Time [sec]		
Mean ± SD	84.76 ± 51.11	77.92 ± 37.20
Drying time [sec]		
Mean ± SD	62.64 ± 58.42	9.64 ± 20.66
Time necessary for disinfection [sec]		
Mean ± SD	162.58 ± 92.57	107.04 ± 70.00
Field dimension [%]		
Small	16%	28%
Medium	36%	36%
Large	48%	36%
Cases of dirtying floor [%]	20%	0%
Drapes been used for floor cleaning [%]	16%	0%
Number of drapes used for floor cleaning		
Mean ± SD	1.12 ± 0.35	0.0 ± 0.0
Median (Interquartile Range)	1 (IQR: 1-1)	0 (IQR: 0-0)

kit) or surgical instruments were never used, in the Betadine group (except in one case) gauzes and surgical instruments were used with median values equal to 2 and 1 respectively ($p < 0.001$ for both comparisons from Mann Whitney U test). Mean number of gauzes was instead equal to 1.76 ± 1.02 whereas the mean number of instruments utilized was 1.52 ± 0.99 . Imbued swabs were used in 15 cases in the Betadine group with a median value of 0 but an interquartile range [0,1], (mean \pm SD: 0.40 ± 0.67), whereas extra pair of gloves was used in 7 cases. In the ChloroPrep group no swabs out of kit nor extra pair of gloves were used and the Mann-Whitney U test for these two comparisons resulted significant.

Towels/gauzes used to dry the field were used in the Betadine group in 47 cases with a median number of 2 (IQR: 1-2) and with a mean value of 1.62 ± 0.35 . In none of the surgical operations of the ChloroPrep group towels or gauzes were used to dry the field ($p < 0.001$ from Mann Whitney U test).

The floor was soiled in 10 cases (20%) when Betadine was used and was never soiled in the ChloroPrep group ($p = 0.001$ from Fisher's Exact Test). In 8 cases (16%) drapes were used to clean the floor and in 7 out of 8 cases only one drape was used, 2 drapes were used in the remaining 1 case (mean \pm SD: 1.12 ± 0.35).

Comparison Between Betadine and ChloroPrep in Terms of Application Time, Drying Time and Disinfection Time

For each observed surgical operation the field dimension was defined as Small (e.g. hernia), Medium (e.g. cholecystectomy) and Large (e.g. total abdomen). The association between type of disinfectant and Field dimension resulted non-significant ($p = 0.29$ from Chi-Squared Test). However, the variable was still maintained as a block factor in the Analysis of Variance (ANOVA) when time of application, drying and disinfection (that is the time from the beginning of painting to placing of drapes) were compared between the two disinfection groups. For the Application time, overall ANOVA resulted significant ($p < 0.001$); however, the disinfection group and the interaction group \times field resulted non-significant ($p = 0.83$ and 0.69 respectively). Average application times were 84.76 ± 51.11 in the Betadine group vs 77.92 ± 37.20 in the ChloroPrep group. Factor field dimension resulted instead significant ($p < 0.001$), showing a significant increase in application time from small to large fields (see Figure 1A).

For the Drying time, overall ANOVA resulted significant ($p < 0.001$), and while field dimension and interaction group \times field resulted non-significant ($p = 0.73$ and $p = 0.88$ respectively), disinfection group was significant ($p < 0.001$): 62.64 ± 58.42 in the Betadine group vs 9.64 ± 20.66 in the ChloroPrep group (Figure 1B)

ANOVA resulted significant also for the variable Disinfection time ($p < 0.001$). Both factors disinfection group and field dimension resulted significant ($p = 0.007$ and $p = 0.006$ respectively). The average value in the Betadine group was 162.58 ± 92.57 vs 107.04 ± 70 in the ChloroPrep group (Figure 1C).

Questionnaire Analysis

For the items *Ease of activation* and *Ease of application* all the surgeons in all the operations and independently from the used disinfectant answered giving a score of "Excellent"; for the item who evaluated the *Pooling/Puddling of the solution* used as disinfectant, there was a different distributions of the assigned scores between the two groups ($p < 0.001$ from Chi-Squared test), with a score of "Acceptable" for the majority of cases (84%) in the Betadine group and with a score of "Excellent" for the majority of cases (86%) in the ChloroPrep group. A similar pattern was recorded for the item related to *Staunching*: for the Betadine group, in 80% of the operations the surgeons assigned a score of "Acceptable"; for the ChloroPrep group, in 84% of the operations the surgeons assigned a score of "Excellent" ($p < 0.001$). Distribution of answers related to item *Drying time* was significantly different ($p < 0.001$) with 64% of "Unacceptable", 28% of "Acceptable" and 8% of "Excellent" for the Betadine solution and with 0%, 2% and 98% respectively for the ChloroPrep group. As regards *Area covered by solution*, no difference in answers was recorded: 98% vs 100% assigned "Excellent" when Betadine or ChloroPrep were used respectively; for the item *Adhesion of the drapes after drying*, while in all operations where ChloroPrep was used the score was "Excellent", in the Betadine group the distribution of the answers was as follows: 64% "Excellent", 28% "Acceptable" and 8% "Unacceptable" ($p < 0.001$). Figure 2 reports the distributions of the assigned scores to the different items in the two groups.

Discussion

In epidemiology and statistics, an observational study draws inferences about the possible effect of

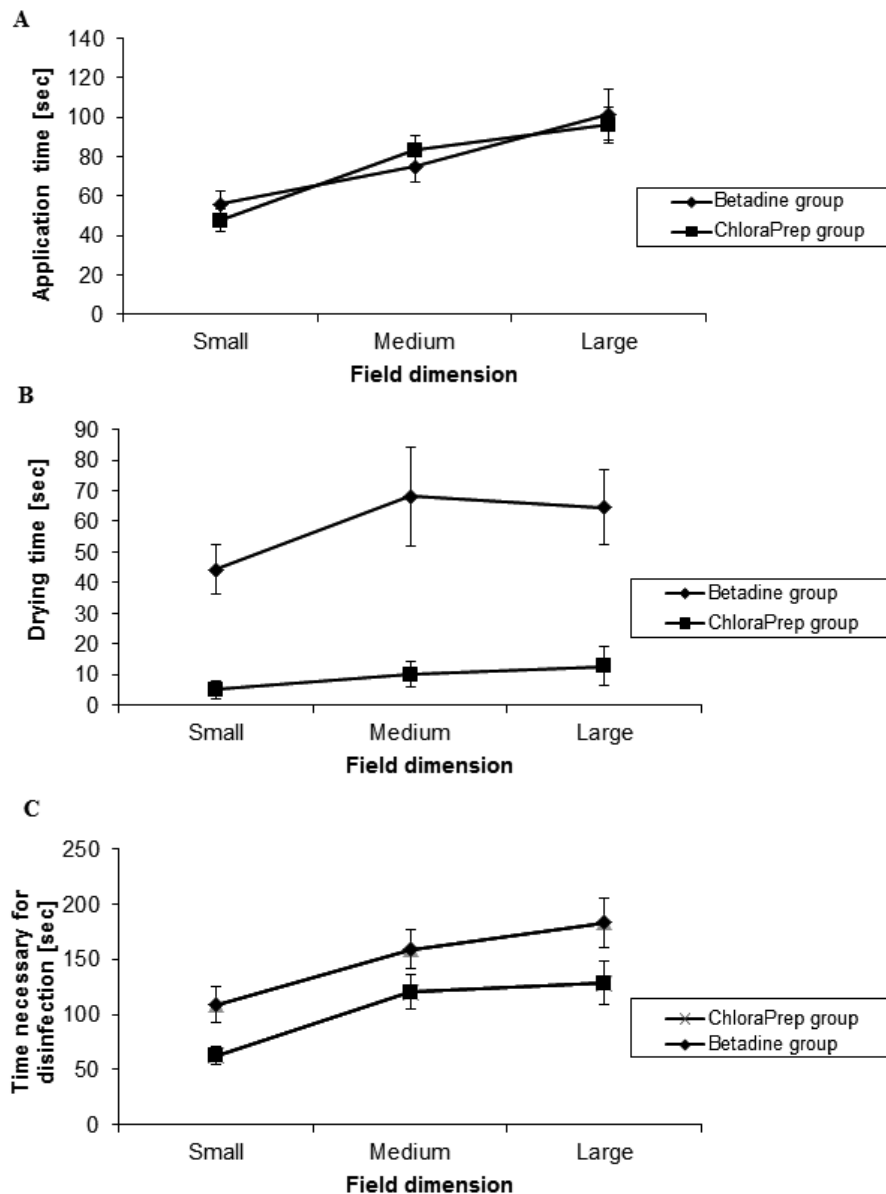


Figure 1. Application time (panel **A**), Drying time (panel **B**) and Disinfection time (panel **C**) in seconds for the Betadine solution (black diamonds) and for ChlorPrep solution (black squares) in the three levels of Field dimension (Small, Medium, Large).

treatment on subjects, where the assignment of subjects into a treated group versus a control group is outside of the control of the investigator⁸. As stated by Richard Nahin⁹: “Although observational studies cannot be used as reliable sources to make statements of fact about the “safety, efficacy, or effectiveness” of a practice, they are of great use for some other things: (1) they can provide information on the “real world” use and practice; (2) detect signals about the benefits and risks of the use of practices in the general population; (3) help formulate hypotheses to be tested in subsequent experiments; (4) provide part of the community-level da-

ta needed to design more informative pragmatic clinical trials; a (5) inform clinical practice”.

We decided to perform an observational study on disinfection techniques for surgical field preparation in our hospital to evaluate the direct and indirect costs of these two types of disinfection and also to see if recommended guidelines are utilized for these procedures. Easier procedures are more easily accepted and better performed, and the surgeon’s appreciation is a key factor in optimal compliance to guideline.

Classical disinfection of the surgical field is done by Betadine solution, but recently Chlo-

raPrep 26 mL and 10 mL kits are being also utilized. Do to the reduced sanitary budget in Italy the more costly ChlorPrep is sometimes spared and limited. The results we obtained from this observational study lead us to some considerations.

Cumulative SSI incidence in Italy is not reported by official data. However, it can be approximated to European data reported by Leaper⁵. SSI determine great sanitary costs because they lengthen hospital stay and after discharge they lead to a high

incidence of early readmissions and can basically more than double the cost of the index hospitalization, for example in case of colonic surgery from \$5.500 to \$13.500¹⁰. In this context prevention seems to be the most important factor. Even if disinfection of the surgical field is only one of the elements that may reduce SSI, the adoption of a simpler and more effective disinfectant – even though more costly – should be enforced, because the cost of the disinfectant is really marginal if compared to

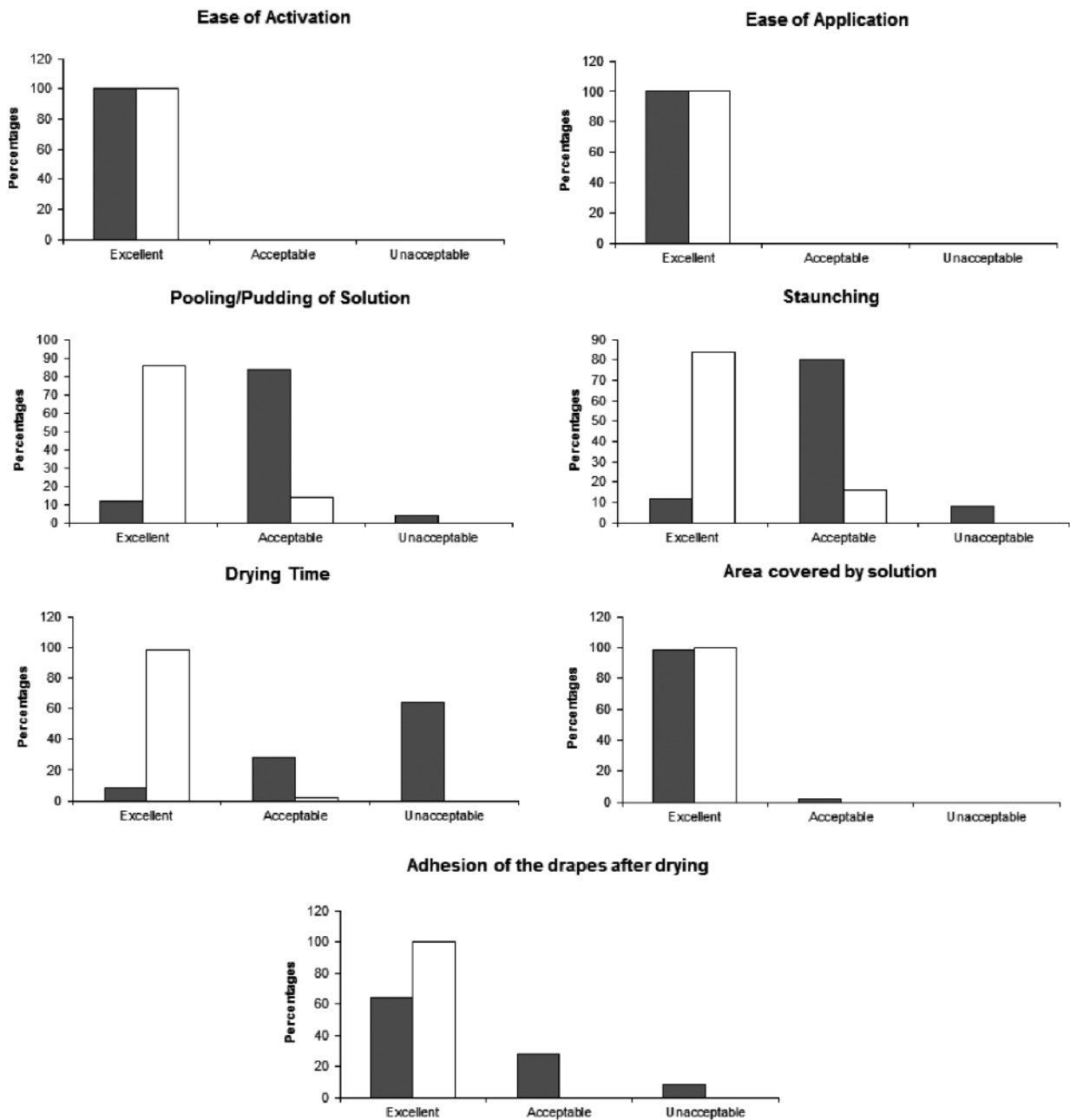


Figure 2. Comparison between Betadine (Grey bars) and ChlorPrep (White bars) solution in terms of percentage distribution in the three scores of each item of the questionnaire submitted to the surgeons at the end of each surgical operation.

the risk of an SSI. A simpler-to-apply disinfection procedure is also advisable because it is more effective. Moreover, costs that must be considered are not only those of the disinfectant but also those of auxiliary material, even if these are negligible in the overall context. Besides, the use of auxiliary materials tends to complicate the disinfection procedure. These criteria have led us to look also at minor costs and at the sympathy of the surgeon towards a particular disinfection technique.

Povidone iodine is not considered today the most efficient disinfectant of the surgical field in the prevention of SSIs^{7,11} and the major infection risk is reported to drop to 9% with chlorhexidine in alcohol in face of a 16% with Betadine disinfection (PVI in aqueous solution). Chlorhexidine has been demonstrated to be superior to Betadine also in methylated spirits solution for reducing colony formed units (CFU), and tentatively it has been suggested to employ this disinfectant also for hand scrubbing¹². The same results of a slight superiority of chlorhexidine over PVI have been obtained also for clean surgical procedures¹³. However, CDC has not issued new Guidelines for the prevention of surgical site infection after 1999, due to the limited number of studies as yet that clearly validate risk factors and prevention measures for SSI¹⁴.

Basically, the criticalities and the inconveniences that have been identified during the preparation of the surgical field with PVI antiseptic touch many aspects.

The standard guidelines for the disinfection are less practical to perform with PVI. In fact, we observed "on the field" that the time spent waiting for the drying of the disinfectant in case of Betadine is a bit longer than that of ChlorPrep. However, guidelines for PVI drying vary among different sites consulted, but there is basic agreement that the disinfectant must be allowed to dry for at least 90-120 seconds in case of small fields, and longer in case of bigger fields¹⁵. In some cases, guidelines even say that the surgeon should wait for the disinfectant to dry without using gauzes to wipe the still wet part off.

This translates into a systematic lengthening of the surgical time of some minutes with PVI, that corresponds to a cost of the operating room. At the same time, the longer is the drying time the greater is the probability that the surgeon decides to wipe off or dry manually the residual disinfectant with the possibility of a contamination of the surgical field and a small break in guidelines.

From this point of view, ChlorPrep does not require drying, in particular manual drying with

gauzes, because drying takes place in a very short time by evaporation of alcohol solvent.

In this respect, we also evaluated the facility of use and the "liking o satisfaction" of disinfection, as subjectively perceived by the operator in the time interval immediately after having completed the procedure. The Betadine ease of use was declared excellent in 100% of cases but drying time was declared unacceptable in 33 on 50 cases and acceptable only in 13 cases.

In conclusion, the simplicity of use and liking of Betadine are good, made exception for the long drying time that sometimes pushes the surgeon to use a paper towel to absorb the residual fluid, and shorten the required time of action. The "wet" effect of the skin after drying leads to a less than ideal adhesion of adhesive surgical drapes to border off the field, while the precise drying on the borders often requires the change of gloves due to contamination.

The auxiliary costs of gauzes, swabs big and small, surgical instruments, gloves, cleaning, etc, even though not systematically present, play a role in about one third of cases of use of PVI solution and by themselves represent a cost of the same order of magnitude of the disinfectant itself.

The adjunctive use of an incision drape (Steri-DrapeTM or IobanTM) changes substantially the cost of surgical field preparation, because it adds a cost of one order superior to the cost of the disinfectant (10 to 20 Euros per device). Since there is no evidence that these devices reduce SSI risk¹⁶, we conclude that their use could be psychologically justified only in a situation of known imperfect skin disinfection and then we must enforce the use of a sound disinfectant and a correct procedure to reduce costs.

The alternative product chlorhexidine in alcohol (ChlorPrep) has many advantages and eliminates part of these drawbacks. Its action is quicker and its activity persists independently from the contamination by body fluids, it presents a residual effect. It does not require auxiliary material for the application and drying. It does not drip off the surgical field and it does not make a mess, and allows a better sticking of the surgical drapes for bordering off the field. The facility of use and the "liking o satisfaction" of disinfection, as subjectively perceived by the operator, are defined "excellent" in almost all items we explored. Moreover, the kits have the characteristics of a systematic application of modern guidelines of the disinfection of the surgical field (that is important for a good clinical surgical practice) also because of its

single use packaging and the fact that the package contains all the instruments necessary for the various steps of surgical field disinfection, including the navel, remembering also these steps to the surgeon by the simple presence of the swab inside the package. For example, the correct navel cleaning took place in every patient disinfected by ChloroPrep operated on the abdomen using the enclosed swabs, while in the Betadine group this procedural detail was accomplished less than in 50% of cases (15 out of 42 abdominal patients).

Conclusions

Our study reveals that the usual Povidone iodine skin disinfection procedure is associated with systematic adjunctive costs from auxiliary materials and operating room time that are of the same order of magnitude of the disinfectant cost itself. If the costs of SSI are taken in to account, that are largely prevalent over the cost of surgical field disinfection, we must totally conclude in favour of the most efficacious disinfectant and the most stringent procedure.

Appendix 1

New Cross Skin Prep Evaluation Form			
Date _____			
Name _____		Surname _____	
Nosographic _____			
Product used			
ChloroPrep 26 mL or 10 mL			
Betadine			
Other _____			
Have you had training in the use of this product: YES NO			
Have incision drapes (steridrape, ioban, ect.) been used: YES NO			
If YES, which type? _____ medicated or not: YES NO			
How many ChloroPrep applicators/how much solution used (cc): _____			
Please evaluate			
Attribute	Excellent	Acceptable	Unacceptable
Ease of activation			
Ease of application			
Pooling/puddling of solution			
Staunching			
Drying time			
Area covered by solution			
Adhesion of the drapes after drying			
Number of gauzes for disinfection _____			
Number of surgical instruments used for disinfection _____			
Number of swab imbued _____			
Application time (of disinfectant on the skin) _____			
Drying time (in excess of the above, before asking for drapes) _____			
Field dimension: <input type="checkbox"/> Small (e.g. hernia)			
<input type="checkbox"/> Medium (e.g. cholecystectomy)			
<input type="checkbox"/> Large (e.g. total abdomen)			
Number of used towels/gauzes to dry the field (if any) _____			
Number of gloves used during disinfection _____			
Minutes needed (time necessary) for disinfection (from the beginning of painting to placing of drapes) _____			
Dirtying of floor <input type="checkbox"/> YES <input type="checkbox"/> NO			
Have drapes been used for floor cleaning <input type="checkbox"/> YES <input type="checkbox"/> NO			
If YES, how many? _____			
Any other comment			

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