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RESEARCH

A survey of propofol injection practices reveals poor knowledge of and unsatisfactory adherence to the SASA Guidelines for Infection Control

Anneme Breedt[a], Johan (Jeff) F. Coetzee[a]*, Hyla Kluyts[b] and Pamela Scheepers[a]

[a]*Anesthesiology and Critical Care, Stellenbosch University, Tygerberg, South Africa*
[b]*Department of Anaesthesiology, School of Medicine, University of Pretoria, Gezina, South Africa*
**Corresponding author, email: jfc@sun.ac.za*

Background: Propofol lipid emulsion supports bacterial growth and various outbreaks of postoperative infection are attributed to extrinsic contamination. This study's objectives were to ascertain propofol administration practices among South African anaesthesiologists and to determine the influence of the 2014 South African Society of Anaesthesiologists (SASA) Guidelines for Infection Control in Anaesthesia.
Methods: A total of 1 598 SASA members were invited to participate anonymously and 634 replies were received. Using a risk-scoring system developed from 13 questionnaire items, 542 respondents who administer propofol infusions were stratified into Low-, Moderate-, High- and Very High-Risk groups.
Results: The majority (65%) of the 542 participants who administer propofol infusions were classified as Moderate Risk, 29% as Low Risk and 6% as High and Very High Risk. Some 61% were aware of the SASA Guidelines, of whom 47.3% had studied them. The median risk-score of the Studied Guidelines group was significantly smaller ($p < 0.001$). They included a greater proportion who were categorised as low risk (58% vs. 45%) and a lower proportion who were moderate risk (38% vs. 51%). Proportions of high-risk individuals did not differ. Of the total 634 respondents, 247 used rubber-stoppered vials of whom 28% had studied the SASA Guidelines; 20% of the Studied Guidelines group often/always shared vial contents between patients versus 12% of those who had not studied them ($p = 0.13$). Conversely, 40% (studied group) versus 13.6% (not-studied group) often/always wiped the diaphragm and seldom/never shared vial contents between patients ($p < 0.0001$). In all, 25% of the total 634 respondents often/always pre-prepared multiple propofol syringes; 5.0% diluted propofol and often/always pre-prepared syringes.
Conclusion: Penetration of the SASA Guidelines was low. Differences in unsafe practices among anaesthesiologists who had read the guidelines were statistically significant but clinically inconsequential. This highlights a need for greater publicity, emphasising their practical importance.

Keywords: drug compounding, Infection control, propofol, postoperative complications, practice guidelines as topic

Introduction

Anaesthetic workspaces in South Africa are prone to contamination, with subsequent risk of intraoperative transmission of pathogenic microorganisms.[1,2] Propofol, being dissolved in a lipid emulsion of soya bean oil, glycerol and egg lecithin, is capable of supporting rapid bacterial and fungal growth[3–12] as well as promoting endotoxin production.[3] Furthermore, stability of hepatitis C virus in propofol has been demonstrated.[13] Reports of infections related to extrinsically contaminated propofol resulting from unsafe injection practices have appeared regularly since 1990.[14–23] Centres for disease control and anaesthetic associations,[24–29] including the South African (SA) Association of Anaesthesiologists (SASA)[30] have published guidelines for prevention of anaesthetic-related infections. With regard to safe injection practices, all agree that syringes, needles, administration sets, ampoules and vials are for single use only and containers should be wiped with an alcohol swab before breaking the ampoule or penetrating the vial diaphragm. Furthermore, propofol should be discarded within 6 h and in the intensive care unit (ICU) within 12 h. The United States of America's Centers for Disease Control and Prevention (CDC) are conducting a '*One and Only Campaign*' to raise awareness regarding safe injection practices amongst healthcare professionals and patients.[31] Despite these efforts, it appears that in several countries unsafe injection practices persist among anaesthetists.[32–35] The SA Medicines Control Council issued a warning during 2000 concerning outbreaks of postoperative infections, involving 10 patients (including one fatality) that resulted from unsafe injection practices involving propofol.[36] Recently a survey among 91 anaesthetists working in 15 hospitals in KwaZulu-Natal revealed that unsafe injection practices were common.[37]

The primary objectives of this study were: (1) To ascertain propofol injection practices among South African anaesthetists regarding the risk of infection transmission by means of a survey; (2) To determine the influence of the SASA Guidelines for Infection Control in Anaesthesia in South Africa 2014 (SASA Guidelines) on the propofol injection practices of SA anaesthetists. Secondary objectives were: (a) To determine whether propofol injection practices differed according to level of training (registered specialist vs. non-specialist), sector employed (private vs. public) and gender; (b) To estimate the prevalence of target-controlled infusions (TCI) among SA anaesthetists.

Methods

Approval for the study was obtained from the Health Research Ethics Committee (HREC) of the Faculty of Medicine & Health Sciences of Stellenbosch University, SA; (Institutional Review Board (IRB) Number: IRB0005239, Protocol Number S15/09/198). The survey was conducted in collaboration with the Anaesthesia Network for South Africa (ANSA), a SASA initiative that supports national collaborative research. Permission to conduct the survey amongst SASA members was obtained and ANSA was authorised by SASA to survey members on our behalf. SASA

membership is approximately 1 700. We included registrars, associate members (general practitioner anaesthetists) and specialist anaesthesiologists in public and private practice who were accessible by email. Nurse members and members residing in other countries were excluded. Retired members who did not respond to the survey invitation, and whose contact details had not been updated, were excluded. We developed the questionnaire and collected the data using the Research Electronic Data Capture Consortium (REDCap) system, a secure application developed at Vanderbilt University.[38] The list of survey questions is presented in Appendix A.

An email invitation to participate in the survey was distributed to SASA members during November 2015. Potential participants were assured of anonymity, and informed about the purpose of the study and approval by SASA and HREC. By responding, the participant granted consent that his/her responses be used for the study. The invitation contained a link to the electronic questionnaire. Completed questionnaires were captured automatically and stored on a secure server. An incentive in the form of a prize could be won through a process of random selection. Non-responders received three reminders at 10-day intervals. Additional invitations to participate were distributed to non-responders during January 2016, followed by two reminders at 10-day intervals. We concluded the survey during February 2016. The sponsor's identity was revealed with the name of the prize-winner. Data were exported from the REDCap database to a comma-delimited file and imported to Microsoft Excel® (Microsoft Corp, Redmond, WA, USA).

Calculation of risk score

We constructed a risk-scoring system from the possible replies to 13 questions regarding handling of propofol ampules and syringes that we regarded as constituting infection risks (Appendix B). For example, in reply to the question 'Do you draw up leftover contents of a propofol glass ampule for the next patient?', scores of 0, 1, 2 and 3 were allocated to the replies 'Never', 'Rarely', 'Often' and 'Always' respectively. The maximum total was 39. Scores were grouped into Low-, Moderate-, High- and Very High-Risk categories (Appendix B, Table 2). Risk scores were applied to the replies by the respondents, who indicated that their practices included administration of propofol by infusion. Rubber-stoppered vial usage was not included in the risk-score calculations and was analysed separately because only a minority of respondents were propofol vial users.

Statistical analysis

Statistical analysis was performed using MedCalc software.[39] Non-parametric methods were employed, the data being ordered and categorical. Risk scores were compared using the Mann–Whitney test when comparing two groups and Kruskal–Wallis one-way analysis of variance for more than two groups, followed by multiple comparisons. Proportional data were compared using the chi-square test. An alpha value < 0.05 was accepted as statistically significant. Confidence intervals for the differences between two median values were calculated using Confidence Interval Analysis (CIA) software.[40] CIA employs the Hodges–Lehmann estimator for calculating a confidence interval between two population medians, described by Conover[41] and outlined in the book Statistics with Confidence by Altman *et al.*[42]

Results

We issued 1 598 invitations and received 634 satisfactorily completed replies (39.7%). Participants' mean age was 46.3 years (SD 11.6, range 26–78 years). Table 1 portrays their demographics as well as several key responses.

Risk-scores analysis

Risk scores were applied to the replies by the 542 respondents who indicated that they administered propofol by infusion. The median infection-risk score was 11 (Range 0–27; IQR 8–14; 95% confidence interval (95% CI) 10–11). One participant was classified as Very High risk. Participants' scores and the frequency of scores in the various risk categories are portrayed in Figure 1 and Table 2. The majority of the 542 participants (65%) were classified as Moderate- Risk. The next largest grouping was Low Risk (29%). High Risk and Very High Risk together comprised 6%.

Table 1: Demographics of and certain responses of interest by the 634 respondents

Factor	Proportion of total	Number
Participants	100%	634
Females	36.3%	230
Private sector	66%	417
Registered specialists	77%	488
Trainees	13%	81
General practitioners	10%	65
Aware of SASA Guidelines	62%	393
Studied SASA Guidelines	29%	185
Read package insert	52%	332
Pre-prepares multiple syringes	45%	283
Pre-prepares often	21%	133
Pre-prepares always	3.6%	23
Sometimes dilutes propofol	18%	112
Often/always pre-prepares syringes *and* dilutes propofol	5.0%	32
Adds ketamine to propofol often/ always	6.2%	39
Will draw up ketamine from previously used vial	16%	102
Adds remifentanil to propofol often/ always	14%	90

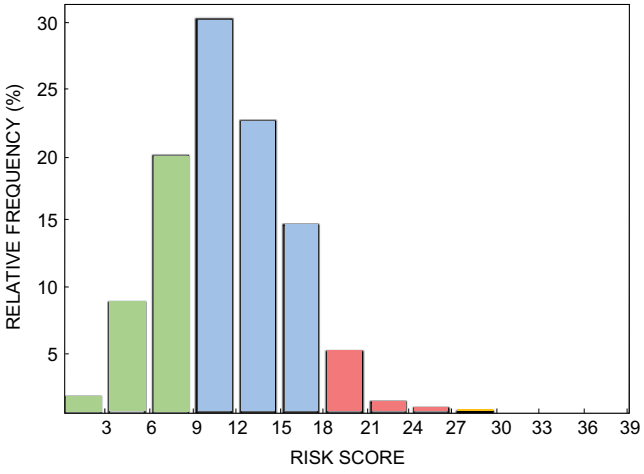

Figure 1: Histogram illustrating the distribution of the risk scores of the 542 respondents who indicated that they administer propofol by infusion. Green = Low risk (0–8); Blue = Moderate risk (9–17); Red = High risk (18–26); Yellow = Very high risk (27–39).

Table 2: Risk scores of the 542 participants who administer propofol by infusion, categorised from Low to Very High Risk

Category	*n*	Median	IQR	Range	95% CI
Low (0–8)	156 (28.8%)	6	5–8	0–8	5.7–6.3
Moderate (9–17)	353 (65.1%)	12	10–14	9–14	10–12
High (18–26)	32 (5.9%)	19	18–20	18–26	18–19
Very High (27–39)	1 (0.2%)	–	–	–	–

Notes: *n* = number of respondents (percentage of the 542 respondents).
IQR = interquartile range.
95% CI = 95% confidence interval of the median value.

Table 3: Contributions by the 542 ranked responses to the total number of infection-risk points. The first five ranked responses contributed 75% to the total score

Rank	Participant response	Points	Proportion
1	Does not wipe neck of propofol ampoule before breaking it	1532	25.6%
2	ICU propofol infusions: Change after > 12 h	900	15.1%
3	Propofol infusions: refills the 50 ml syringe	832	13.9%
4	More propofol for the same patient using a previously used syringe	667	11.2%
5	Uses a previously used needle to draw up more propofol	534	8.9%
6	Pre-prepares multiple propofol syringes	395	6.6%
7	Dilutes propofol	300	5.0%
8	Shares propofol ampoules between patients	297	5.0%
9	Infusions: Reuses 50 ml syringes between patients	179	3.0%
10	Bolus dosage: Reuses syringes between patients	135	2.3%
11	Carries over propofol from the a.m. to the p.m. list	102	1.7%
12	Uses the same extension tubing between patients	62	1.0%
13	In the OR: Time within which the propofol must be used after opening the ampoule	42	0.7%
	Total	5977	100%

The extent to which the answers to each question contributed to the total of all the scores was obtained by calculating the total scores resulting from each of the 13 questions and expressing them as a percentage of the overall total (Table 3). The first five of the ranked responses contributed 75% to the total.

Impact of the SASA Guidelines on infection-risk scores

Of the 542 scored respondents, 332 (61.3%) were aware of the SASA Guidelines, of whom 157 (47.3%) had studied them (29% of the 542). The impact of the SASA Guidelines is presented in Table 4 and Figure 2. The median risk score of those who had studied the SASA Guidelines was significantly lower than those who had not ($p < 0.001$); however, the difference was small (95% CI 1–2 points). The studied-SASA-Guidelines group had a greater proportion of respondents who were categorised as Low Risk (58.4% vs. 45.2%, $p = 0.0026$) and a lower proportion who were categorised as Moderate Risk (38.4% vs. 50.8%, $p = 0.0045$). There was no difference between the proportions of High-Risk individuals (3.2% vs 4.0%, $p = 0.646$).

Table 4: Risk scores according to various categories of respondents who administered propofol infusions (Total respondents 542)

Factor		*n*	Median (IQR)	Range	*p*	95% CI Difference
Guidelines	Studied	157	10 (7–13)	2–27	0.001	1–2
	Not studied	385	11 (9–14)	0–24		
Sector	Public	196	11 (8–14)	2–21	0.98	−1–1
	Private	346	11 (8–14)	0–27		
Training level	Specialist	414	11 (8–14)	0–27	0.038	0–2
	Non-specialist	28	10 (8–12)	2–24		
Gender	Male	342	11 (8–14)	0–27	0.53	−1–1
	Female	200	11 (8–14)	2–21		

Notes: *n* = number of respondents; IQR = interquartile range;.
95% CI Difference = 95% confidence interval of the difference between median scores.
Score categories: Low Risk 0–8; Moderate Risk 9–17; High Risk 18–26; Very High Risk 27–39.

Of the 157 who had studied the guidelines, 56 (35.7%) stated that they had subsequently changed their practices: 55 stated how their practices had changed (Appendix C). There was no significant difference in median risk scores between those who stated that they had changed their practices vs. those who had not (9, IQR 7–12, vs. 10, IQR 7–13, $p = 0.12$, Figure 3). None of those who stated that they had changed their practices achieved High-Risk scores, whereas eight of those who had not changed their practices did achieve High-Risk scores (median 18, range 18–27, one-tailed probability for Fisher's exact test $p = 0.026$). There was no difference between the two groups with regard to the proportions who achieved Low-Risk scores ($p = 1.0$).

Influence of training level, employment sector, gender and age on infection-risk scores (Table 4)

The median score of non-specialists was statistically significantly smaller than that of the specialist group ($p = 0.038$); however, the difference was trivial (95% CI 0–2 points). There were no significant differences between the median scores of practitioners working in the private vs. the public sector or males vs. females. There was no association between age and risk score (Spearman's rho = 0.003, $p = 0.94$).

Rubber-stoppered vial usage

Of the 634 respondents, 247 (40%) use rubber-stoppered vials. The majority (73.7%) worked in the private sector. Vial usage is depicted in Table 5. Notably with regard to low-risk behaviour, 62.3% never share vial contents between patients; 21.1% stated that they always or often swabbed the diaphragm *and* never or seldom shared vial contents between patients. In terms of high-risk behaviour, 57.9% never swab the diaphragm; 11.7% stated

Table 5: Rubber stoppered vial usage (247 respondents)

Factor	Total	Always	Often	Rarely	Never
Swab diaphragm with alcohol	104 (42.1%)	34 (13.8%)	25 (10.1%)	45 (18.2%)	143 (57.9%)
Allow diaphragm to dry (% of 104)	87 (83%)	41 (39.4%)	18 (17.3%)	28 (26.9%)	17 (16.3%)
Share contents	93 (37.7%)	3 (1.2%)	33 (13.4%)	57 (23.1%)	154 (62.3%)

Note: Percentages are expressed as proportions of 247 respondents, unless stated otherwise.

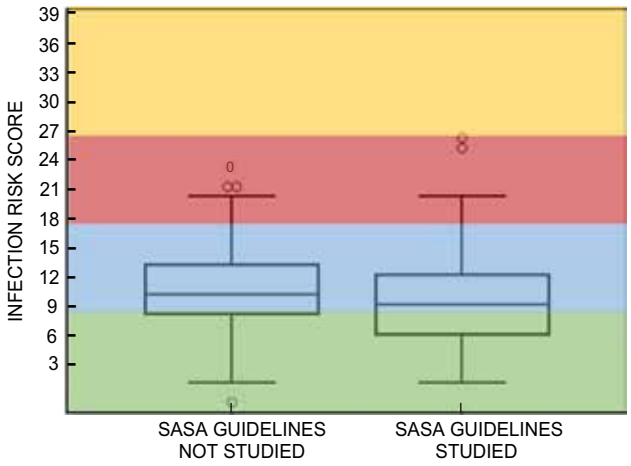

Figure 2: Box and whisker plots illustrating the influence of the South African Society Guidelines for Infection Control in Anaesthesia in South Africa 2014 on the infection risk scores of participants who had read them versus those who had not. Green = Low risk; Blue = Moderate risk; Red = High risk; Yellow = Very high risk. SASA Guidelines = South African Society Guidelines for Infection Control in Anaesthesia in South Africa 2014.

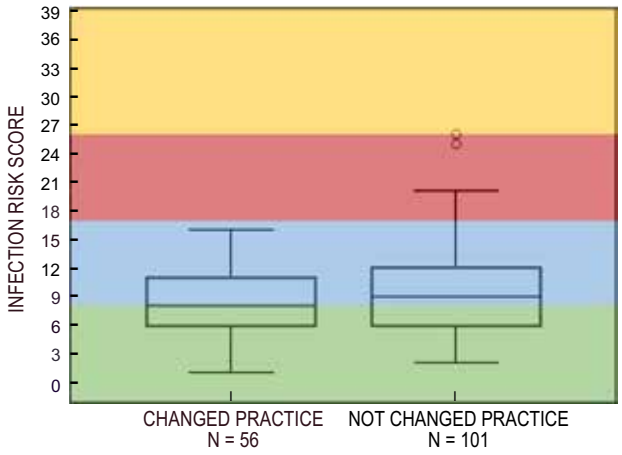

Figure 3: Box and whisker plots illustrating infection risk scores of practitioners who, after having read the SASA guidelines, changed their practices vs. those who had not. Green = Low risk; Blue = Moderate risk; Red = High risk; Yellow = Very high risk.

that they never or seldom swabbed the diaphragm *and* always or often shared the vial contents.

Impact of the SASA Guidelines on rubber-stoppered vial usage

Seventy of the 247 respondents (28.3%) who use rubber-stoppered vials had studied the SASA Guidelines. The effect on those who had studied the SASA Guidelines is portrayed in Table 6.

Prevalence of target-controlled propofol infusions

Most (95.5%) respondents who administer propofol by infusion stated that they administered propofol by target-controlled infusion (TCI) (518/542). The median percentage of patients to whom these respondents administered TCI was 20% (IQR 10–37%; 95% CI 17–21%; range 1–100%). Seventy-five respondents stated that they administered TCI for 75% or more of their cases. Figure 4 depicts a frequency histogram of the distribution of TCI infusions.

Discussion

Only 29% of participants who administer propofol infusions were classified as being of low risk, the majority (65%) scoring in the moderate-risk category. This is a disconcerting finding, as, in addition, a significant proportion (6%) scored as High Risk or Very High Risk. Prior to publication of the SASA Guidelines, a survey conducted among 91 anaesthetists in KwaZulu-Natal[37] found that 14% of the participants admitted to the reuse of syringes on different patients; 19% reused syringes on different patients after changing the needle or infusion set. Similar behaviour was demonstrated in our study, despite it being conducted after publication of the SASA Guidelines. In our study, 16% admitted to using the same propofol syringe for different patients and 21% to reusing 50 ml syringes for propofol infusions. Of these, 30% reuse extension tubing between patients. Thus it appears that little change in clinical practice has occurred since publication of the SASA Guidelines. It is concerning that 44% of the total of 634 participants pre-prepared multiple syringes (21% often and 3.6% always). It is of particular concern that 8.8% of participants diluted the propofol *and* pre-prepared syringes. These actions are particularly prone to transmission of infection, considering the contaminated environment of many SA operating rooms and that pre-prepared syringes may end up being used some hours after preparation. Vial usage was also disconcerting as 57.9% indicated that they never swab the diaphragm with an alcohol swab. Only 21% always or often swabbed the diaphragm *and* never or seldom shared the contents between patients. Furthermore almost 12% never or seldom swabbed the diaphragm *and* always or often shared the vial contents. Studying the SASA Guidelines did influence vial handling significantly, as 40% often/always wiped the diaphragm *and* seldom/never shared vial contents between patients versus 13.6% who had not studied the guidelines.

Failure to wipe the neck of the propofol ampoule made the greatest contribution to risk scores (Table 3). Zacher *et al.* demonstrated that wiping the ampoule neck with alcohol prior to opening significantly reduced bacterial contamination of propofol ampoules.[43] This is of particular importance when preparing propofol infusions for TCI or total intravenous anaesthesia (TIVA), or for sedation during critical care, where the solution may be administered over several hours. The second major contributor related to the duration of propofol infusions in the intensive care unit (ICU) whereby participants were prepared

Table 6: Propofol vial usage: influence of the SASA Guidelines on high-risk and low-risk behaviour

Factor		Studied SASA Guidelines (*n* = 70)	Not-studied SASA Guidelines (*n* = 177)	*p*
High risk behaviour	Share vial contents between patients often/always	14 (20%)	22 (12.4%)	0.13
Low risk behaviour	Wipe diaphragm often/always AND share contents seldom/never	28 (40%)	24 (13.6%)	< 0.0001

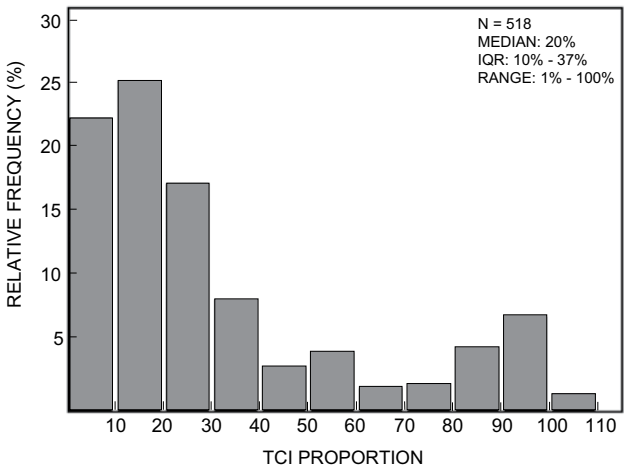

Figure 4: Practitioners who administer propofol using target-controlled infusions (TCI): Histogram illustrating the percentages they administer by TCI. TCI proportion = the proportion that TCI comprises practitioners' infusion administrations. N = number of practitioners; IQR = interquartile range.

to allow more than 12 h to elapse before discarding propofol and giving sets. Of particular concern is that propofol intended for sedation is often diluted prior to administration, itself a risky action. Propofol package inserts clearly state that although propofol may be diluted with four parts of 5% glucose or 0.9% sodium chloride, it should be done aseptically. The United States Pharmacopeial Convention (USP) stipulates that compounding of medications should be conducted in an ISO-5 class environment (less than 3 520 particles of size 0.5 µm and larger per cubic metre) and that this is not achievable within the operating room environment.[44]

An appraisal of 58 studies regarding propofol-related infections, including 20 outbreaks involving 144 patients and 10 deaths,[22] identified syringes, micro-droppers, vials, and IV stopcock dead space as the most frequently encountered reservoirs of extrinsically contaminated propofol, with previously used vials being the most common culprits. Of the infection outbreaks, hepatitis C contributed 18.1%, hepatitis B 4.2%, *Candida albicans* 21.5% and bacteria 47.2% (gram-positive 27.1%, gram-negative 20.1%). The incidence of contaminated syringes was approximately 6% in ICUs and operating rooms. The authors point out that these reports were all from industrialised countries (USA, UK, Europe, Australia and Taiwan) and they were of the opinion that propofol-related infections are under-reported. No reports from developing or low-income countries have been forthcoming where the problem is likely to be much greater due to economic restraints and lack of awareness leading to reuse of syringes, ampoules and vials.

EDTA (ethylenediaminetetraacetic acid) can retard the 24-h growth of microorganisms 10-fold thereby reducing the microbial growth potential in propofol to that of a non-lipid medication.[45,46] EDTA is an FDA-required antimicrobial propofol additive, which has reduced the incidence of propofol-related infections from an average of 39 to 9 infections per year.[17] Three propofol formulations are in common use in SA, of which only one (Diprivan®, AstraZeneca) contains EDTA. The package insert stipulates that *Diprivan* is not an antimicrobially preserved agent; the EDTA retards bacterial growth, but does not prevent it, necessitating asepsis during propofol administration.

Some 62% of the total 634 respondents were aware of the SASA Guidelines but only 29% had studied them. Furthermore only 52% had read a propofol package insert, in which manufacturers warn of the propensity of propofol emulsions to promote bacterial growth and the necessity for aseptic procedures. Studying the SASA Guidelines had a statistically significant impact on participants' propofol handling practices. Besides achieving lower risk scores, those who had studied the guidelines had a greater proportion of low-risk scoring individuals and a smaller proportion with moderate-risk scores. However, both groups had similar proportions of high-risk scoring individuals. Results were analogous with regard to vial handling: Whereas those who had studied the SASA- Guidelines had a greater proportion of practitioners who demonstrated low-risk behaviour, both groups had similar proportions of individuals who admitted to high-risk habits. Thus moderate and high-risk behaviour persists despite studying the SASA Guidelines. We conclude that the influences exerted by the SASA Guidelines, although statistically significant, have been small and probably of no clinical importance.

This study's disappointing result is not unique. A survey amongst 493 American Society of Anesthesiologists (ASA) members reported that 34.4% never or rarely swabbed rubber-stoppered vials and 20% often or always reused syringes.[47] Those who had read the CDC guidelines for the prevention of occupational transmission of HIV/HBV were more likely to have good hygienic practices, but the association, although statistically significant, was weak ($r^2 = 0.036$) and furthermore they were not more likely to swab vials than those who had not read the guidelines. A similar survey among 272 New Zealand anaesthetists[34] reported that 32.4% had never read the national policy on infection control[24]; 86.3% reused ampules between patients, 41.3% reused vials and 2.2% reused syringes. A five-hospital audit in south-east England[48] reported that only 49% of anaesthetists knew the Association of Anaesthetists guidelines. A survey among 1 015 ASA members[49] found that 58% reused syringes between patients and 66% reused needles to draw up drugs.

The large number of anaesthesiologists who practise TCI for a considerable number of cases indicates how readily the SA

anaesthesiology profession has accepted the technology. However, because of the potential for long-duration infusions, our results emphasise the necessity for these practitioners to adopt safe injection practices.

Ketamine has been shown to exert antibacterial and antifungal activity[50] and, considering that it is also pharmaceutically compatible with propofol,[51] it may be argued that propofol–ketamine mixtures may reduce the risk of infection due to extrinsic contamination. Begec *et al.*[50] studied the growth rates of several micro-organisms and the minimal bactericidal concentrations of ketamine in mixtures with 1% propofol (without EDTA). Ketamine retained microbial activity for certain organisms, but at different concentrations. Growth of *Staphylococcus aureus* was not inhibited at the highest tested ketamine concentration. They warned that although propofol–ketamine mixtures may reduce the risk of infection caused by accidental contamination, ketamine's antibacterial activity varies and may be ineffective against certain pathogens. Furthermore we are not aware of studies documenting antiviral activity.

Apan *et al.* investigated the growth rates of several micro-organisms in mixtures of remifentanil and 1% propofol.[52] They demonstrated concentration-dependent growth retardation, which they attributed to the presence of glycine, a buffer in remifentanil ampoules. However, no bactericidal activity was demonstrated, necessitating aseptic precautions. It should be noted that mixing propofol with other drugs technically constitutes a 'new drug' not approved by the SA Medicines Control Council. This has medicolegal implications, as the anaesthesiologist assumes responsibility for any side-effects/complications.

The response rate to our survey was 39.7%, similar to two previous surveys (41% and 44%),[47,49] but lower than the Ryan study (61%).[34] Contributing factors were technical problems experienced with the SASA website, necessitating repeated emails to ensure that all members received invitations. Furthermore invitations were sent under the auspices of ANSA, a newly established, little-known SASA entity, thus some members may have ignored the emails. Nevertheless we regard 634 completed responses as a suitably representative sample of the SASA membership.

Weaknesses of this study include an unvalidated risk-scoring system, but it would be unethical to validate the system by means of a randomised controlled trial. Additionally we did not enquire into other important infection-control practices, specifically hand-washing and glove usage.

Conclusion

Persistent inadequacies regarding the safe administration of propofol reveal that the SASA Guidelines were of low impact. With regard to those who had studied the guidelines, statistically significant differences in injection practices were small and probably not clinically important. In addition, only 60% of respondents were aware of the SASA Guidelines, of whom less than half had read them. More effort is required to persuade SA anaesthetists to comply with the safe injection practices outlined by the SASA Guidelines as well as the package inserts of the propofol suppliers. It is noteworthy that no reports of infection associated with propofol usage have occurred where safe injection practices have been followed.[53] Improved compliance is in the best interest of practitioners and patients alike.

ORCID

Johan (Jeff) F. Coetzee http://orcid.org/0000-0002-9925-7767

References

1. Samuel RA, Gopalan PD, Coovadia Y, et al. Infection control in anaesthesia in regional, tertiary and central hospitals in KwaZulu-Natal. Part 2: Equipment contamination. South Afr J Anaesth Analg. 2013;19(3):146–51.
2. Samuel RA, Gopalan PD, Coovadia Y, et al. Infection control in anaesthesia in regional, tertiary and central hospitals in KwaZulu-Natal. Part 3: Decontamination practices. South Afr J Anaesth Analg. 2013;19(3):204–11
3. Arduino MJ, Bland LA, McAllister SK, et al. Microbial growth and endotoxin production in the intravenous anesthetic propofol. Infect Control Hosp Epidemiol. 1991;12(9):535–9. https://doi.org/10.2307/30145228
4. Aydin N, Gultekin B, Ozgun S, et al. Bacterial contamination of propofol: the effects of temperature and lidocaine. Eur J Anaesthesiol 2002;19(6):455–8. https://doi.org/10.1017/S026502150200073X
5. Berry CB, Gillespie T, Hood J, et al. Growth of micro-organisms in solutions of intravenous anaesthetic agents. Anaesthesia 1993;48(1):30–2.
6. Fukada T, Ozaki M. Microbial growth in propofol formulations with disodium edetate and the influence of venous access system dead space. Anaesthesia 2007;62(6):575–80. https://doi.org/10.1111/ana.2007.62.issue-6
7. Ozer Z, Ozturk C, Altunkan AA, et al. Inhibition of bacterial growth by lignocaine in propofol emulsion. Anaesth Intensive Care 2002;30(2):179–82.
8. Sakuragi T, Yanagisawa K, Shirai Y, et al. Growth of Escherichia coli in propofol, lidocaine, and mixtures of propofol and lidocaine. Acta Anaesthesiol Scand. 1999;43(4):476–9. https://doi.org/10.1034/j.1399-6576.1999.430418.x
9. Strachan FA, Mansel JC, Clutton RE. A comparison of microbial growth in alfaxalone, propofol and thiopental. J Small Anim Pract. 2008;49(4):186–90. https://doi.org/10.1111/j.1748-5827.2007.00473.x
10. Tessler M, Dascal A, Gioseffini S, et al. Growth curves of Staphylococcus aureus, Candida albicans, and Moraxella osloensis in propofol and other media. Can J Anaesth. 1992;39(5 Pt 1):509–11. https://doi.org/10.1007/BF03008718
11. Thomas DV. Propofol supports bacterial growth. Br J Anaesth. 1991;66(2):274. https://doi.org/10.1093/bja/66.2.274-a
12. Wachowski I, Jolly DT, Hrazdil J, et al. The growth of microorganisms in propofol and mixtures of propofol and lidocaine. Anesth Analg. 1999;88(1):209–12.
13. Druce J, Catton MG, Ryan G, et al. Survival of a hepatitis C virus surrogate in anaesthetic and analgesic drugs. Aust Infec Control 2001;6(3):89–90. https://doi.org/10.1071/HI01089
14. Bennett SN, McNeil MM, Bland LA, et al. Postoperative infections traced to contamination of an intravenous anesthetic, propofol. N Engl J Med. 1995;333(3):147–54. https://doi.org/10.1056/NEJM199507203330303
15. Greene ES. Hepatitis C Outbreak: More than 50 infected by reused needles and syringes. ASA Newsletter. 2002;66(12):25.
16. Henry B, Plante-Jenkins C, Ostrowska K. An outbreak of Serratia marcescens associated with the anesthetic agent propofol. Am J Infect Control 2001;29(5):312–5. https://doi.org/10.1067/mic.2001.117043
17. Jansson JR, Fukada T, Ozaki M, et al. Propofol EDTA and reduced incidence of infection. Anaesth Intensive Care 2006;34(3):362–8.
18. Kuehnert MJ, Webb RM, Jochimsen EM, et al. Staphylococcus aureus bloodstream infections among patients undergoing electroconvulsive therapy traced to breaks in infection control and possible extrinsic contamination by propofol. Anesth Analg 1997;85(2):420–5.
19. McNeil MM, Lasker BA, Lott TJ, et al. Postsurgical Candida albicans infections associated with an extrinsically contaminated intravenous anesthetic agent. J Clin Microbiol. 1999;37(5):1398–403.
20. The Joint Commission. Preventing infection from the misuse of vials. Oakbrook Terrace, IL: Sentinel Event Alert: The Joint Commission; 2014.
21. Veber B, Gachot B, Bedos JP, et al. Severe sepsis after intravenous injection of contaminated propofol. Anesthesiology 1994;80(3):712–3. https://doi.org/10.1097/00000542-199403000-00050

22. Zorrilla-Vaca A, Arevalo JJ, Escandon-Vargas K, et al. Infectious disease risk associated with contaminated propofol anesthesia, 1989-2014(1). Emerg Infect Dis. 2016;22(6):981–92. https://doi.org/10.3201/eid2206.150376
23. Muller AE, Huisman I, Roos PJ, et al. Outbreak of severe sepsis due to contaminated propofol: lessons to learn. J Hosp Infect. 2010;76(3):225–30. https://doi.org/10.1016/j.jhin.2010.06.003
24. ANZCA. Guidelines on infection control in anaesthesia.Melbourne: Australian and New Zealand Colleges of Anaesthetists, 2011.
25. Berry AJ. The Anesthesia Patient Safety Foundation (APSF) Recommendations for Handling Parenteral Medications Used for Anesthesia or Sedation. 1995. Available from http://www.apsf.org/newsletters/html/1999/summer/07sterility.htm
26. Brooks M. Joint Commission Issues Alert on Unsafe Injection Practices. Medscape Medical News: Medscape; 2014.
27. Injection safety guidelines from the centers for disease control and prevention, 2007. Available from http://www.cdc.gov/injectionsafety/PDF/SIPC_PocketCard.pdf
28. Dolan SA, Felizardo G, Barnes S, et al. APIC position paper: safe injection, infusion, and medication vial practices in health care. Am J Infect Control 2010;38(3):167–72. https://doi.org/10.1016/j.ajic.2010.01.001
29. Stackhouse RA, Beers R, Brown D, et al. Recommendations for infection control for the practice of anesthesiology. 3rd ed: American Society of Anesthesiologists, Committee on Occupational Health Task Force on Infection Control, 2011. Available from https://www.asahq.org/For-Members/Standards-Guidelines-and-Statements.aspx
30. SASA WGfICG. SASA Guidelines for Infection Control in Anaesthesia in South Africa 2014. South Afr J Anaesth Analg. 2014;20(1):S1–S39.
31. The centers for disease control and prvention. The one and only campaign. Available from http://www.oneandonlycampaign.org/; http://www.cdc.gov/injectionsafety/1anonly.html
32. el Mikatti N, Dillon P, Healy TE. Hygienic practices of consultant anaesthetists: a survey in the north-west region of the UK. Anaesthesia 1999;54(1):13–8. https://doi.org/10.1046/j.1365-2044.1999.00661.x
33. Marcus A. Survey finds 'discouraging' injection habits among anesthesiolgists. Anesthesiology News Clinical Anesthesiology 2012, January;38(1).
34. Ryan AJ, Webster CS, Merry AF, et al. A national survey of infection control practice by New Zealand anaesthetists. Anaesth Intensive Care 2006;34(1):68–74.
35. Yaqub KM, Tariq M, Janjua SK, et al. A survey of infection control practices of consultant anaesthesiologists in teaching hospitals of Pakistan. J Coll Physicians Surg Pak. 2007;17(9):523–6.
36. Mehta U, Gunston GD, O'Connor N. Serious consequences to misuse of propofol anaesthetic. S Afr Med J. 2000;90(3):240.
37. Samuel RA, Gopalan PD, Coovadia Y, et al. Infection control in anaesthesia in regional, tertiary and central hospitals in KwaZulu-Natal. Part 1: Unsafe injection practices among anaesthetists. South Afr J Anaesth Analg. 2013;19(1):68-70
38. Harris PA, Taylor R, Thielke R, et al. Research electronic data capture (REDCap) - a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform. 2009;42(2):377–81. https://doi.org/10.1016/j.jbi.2008.08.010
39. MedCalc Statistical Software [program]. version 16.4.3. MedCalc Software bvba, Ostend, 2016. http://www.medcalc.org; 2017.
40. CIA (Confidence Interval Analysis) [program]. version 2.2.0 build 59. Trevor Bryant, University of Southampton, Southampton, United Kingdom, 2011. http://www.som.soton.ac.uk/cia/.
41. Conover WJ. Practical non-parametric statistics. 3rd ed. New York, NY: John Wiley; 1999.
42. Altman DG, Machin D, Bryant TN, et al. Statistics with confidence. 2nd ed. Bristol: BMJ Books; 2000.
43. Zacher AN, Zornow MH, Evans G. Drug contamination from opening glass ampules. Anesthesiology 1991;75(5):893–5. https://doi.org/10.1097/00000542-199111000-00022
44. USP. Pharmaceutical compounding-sterile preparations. Rockville: The United States Pharmacopeial Convention, 2008.
45. Baker MT, Naguib M. Propofol: the challenges of formulation. Anesthesiology 2005;103(4):860–76. https://doi.org/10.1097/00000542-200510000-00026
46. Thompson KA, Goodale DB. The recent development of propofol (DIPRIVAN). Intensive Care Med. 2000;26(Suppl 4):S400–4. https://doi.org/10.1007/PL00003783
47. Tait AR, Tuttle DB. Preventing perioperative transmission of infection: a survey of anesthesiology practice. Anesth Analg. 1995;80(4):764–9.
48. McNamara JT, Stacey SG. Poor anaesthetist hygienic practices - a problem across all grades of anaesthetist. Anaesthesia 1999;54(7):718–9. https://doi.org/10.1046/j.1365-2044.1999.1013w.x
49. Rosenberg AD, Bemstein D, Skovron ML, et al. Are anesthesiologists practicing proper infection control precautions? Anesth Analg 1991;72(2):S228.
50. Begec Z, Yucel A, Yakupogullari Y, Erdogan MA, Duman Y, Durmus M, et al. The antimicrobial effects of ketamine combined with propofol: An *in vitro* study. Braz J Anesthesiol. 2013;63(6):461–5. https://doi.org/10.1016/j.bjan.2012.09.003
51. Donnelly RF, Willman E, Andolfatto G. Stability of ketamine–propofol mixtures for procedural sedation and analgesia in the emergency department. The Canadian Journal of Hospital Pharmacy 2008;61(6):426–30.
52. Apan TZ, Apan A, Sahin S, Cakirca M. Antibacterial activity of remifentanil and mixtures of remifentanil and propofol. J Clin Anesth 2007;19(5):346–50. https://doi.org/10.1016/j.jclinane.2007.02.005
53. Trepanier CA, Lessard MR. Propofol and the risk of transmission of infection. Can J Anaesth. 2003;50(6):533–7. https://doi.org/10.1007/BF03018635

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Appendix A: **The questionnaire**

Propofol usage survey

Invitation to take part in research about propofol usage

Dear anaesthetist

We, a combined study group from Stellenbosch University and the South African Society of Anaesthesiologists (SASA), invite you to take part in a survey concerning propofol injection practices by anaesthetists. It should not occupy more than five minutes of your time. The survey is completely anonymous and the data will be stored and encrypted in such a way that the identity of the participants cannot be retrieved. By participating you agree to your anonymous responses being used for research purposes. As participant, you will be eligible to win a sponsored prize (an iPad Mini). The Stellenbosch University Health Research Ethics Committee 1 has approved the study.

Please help us to gather as much accurate information as possible.

Sincerely

The propofol usage study group: JF Coetzee, H Kluyts, P Scheepers and A Breedt

What is your age?	
What is your gender?	Male
	Female
Are you	A registered specialist in anaesthesiology?
	A trainee/registrar?
	A general practitioner?
Do you mainly work in	Public sector?
	Private sector?
Do you wipe the neck of a propofol glass ampoule* with an alcohol swab before breaking it?	Never
	Rarely
	Often
	Always
	(*Glass ampoule as opposed to a rubber-stoppered vial)
Do you allow the alcohol to dry before breaking open	Never
	Rarely
	Often
	Always
Do you draw up leftover contents of a propofol glass ampoule* for the next patient?	Never
	Rarely
	Often
	Always
	(*Glass ampoule as opposed to rubber-stoppered vial)
Do you sometimes use propofol rubber-stoppered vials?	Yes
	No
Do you wipe the rubber diaphragm of a propofol vial with an alcohol swab before penetrating it with a needle?	Never
	Rarely
	Often
	Always
Do you allow the alcohol to dry before penetrating the diaphragm?	Never
	Rarely
	Often
	Always

(*Continued*)

Appendix A. (***Continued***)

Do you use a rubber-stoppered propofol vial for more than one patient?	Never
	Rarely
	Often
	Always
Do you sometimes dilute propofol?	Yes
	No
Do you sometimes draw up more propofol for the same patient using the same previously used syringe?	Never
	Rarely
	Often
	Always
Do you use a new needle?	Never
	Rarely
	Often
	Always
Do you use the same propofol syringe for more than one patient?	Never
	Rarely
	Often
	Always
You are about to begin an operating list of short cases. Do you pre-prepare a number of propofol syringes before starting the first case?	Never
	Rarely
	Often
	Always
Do you sometimes carry over propofol that has been drawn up into a syringe from your morning list to your afternoon list?	Yes
	No
Do you ever carry over any leftover propofol to the next day?	Yes
	No
Within what time frame should propofol be administered after drawing it up into a syringe?	6 hours
	12 hours
	24 hours
Do you administer propofol by infusion?	Yes
	No
For what proportion of cases do you administer propofol by target-controlled infusion (TCI)?	0
	50%
	100%
Do you refill the same 50 ml syringe for the same patient?	Never
	Rarely
	Often
	Always
Do you use the same 50 ml syringe for multiple patients?	Never
	Rarely
	Often
	Always
Do you use the same extension tubing between patients?	Never
	Rarely
	Often
	Always
Do you add remifentanil to the propofol syringe?	Never
	Rarely
	Often
	Always

(*Continued*)

Appendix A. (*Continued*)

Do you add ketamine to the propofol syringe?	Never
	Rarely
	Often
	Always
Are you willing to use a previously used ketamine multidose vial?	Yes
	No
In the ICU, what is the maximum duration of a propofol infusion after which the giving set should be changed?	12 hours
	24 hours
	36 hours
	48 hours
Have you read the propofol package insert?	
	Yes
	No
Are you aware of the 'SASA Guidelines for Infection Control in Anaesthesia in South Africa 2014'?	Yes
	No
Have you had an opportunity to read them?	Yes
	No
Having read the guidelines, have you changed your practice with regard to your handling of propofol?	Yes
	No
In what way have you changed your practice in the handling of propofol?	

Appendix B: **Compilation of the infection-risk score**

Q. No.	Question	Possible answers and scores contributing to thresholds			
		Low risk	Moderate risk	High risk	Very high risk
1	Do you wipe the neck of a propofol glass ampoule with an alcohol swab before breaking it?	Always (0)	Often (1)	Rarely (2)	Never (3)
2	Do you draw up leftover contents of a propofol glass ampoule for the next patient?	Never (0)	Rarely (1)	Often (2)	Always (3)
3	Do you sometimes draw up more propofol for the same patient using the same previously used syringe?	Never (0)	Rarely (1)	Often (2)	Always (3)
4	Do you use a new needle?	Always (0)	Often (1)	Rarely (2)	Never (3)
5	Do you use the same propofol syringe for more than one patient?	Never (0)	Rarely (1)	Often (2)	Always (3)
6	You are about to begin an operating list of short cases. Do you pre-prepare a number of propofol syringes before starting the first case?	Never (0)	Rarely (1)	Often (2)	Always (3)
7	Do you refill the same 50 ml syringe for the same patient?	Never (0)	Rarely (1)	Often (2)	Always (3)
8	Do you use the same 50 ml syringe for multiple patients?	Never (0)	Rarely (1)	Often (2)	Always (3)
9	Do you use the same extension tubing between patients?	Never (0)	Rarely (1)	Often (2)	Always (3)
	Risk category thresholds		**9**	**18**	**27**
			–23%	**–46%**	**–69%**
10	Do you sometimes dilute propofol?	No (0)			Yes (3)
11	Do you sometimes carry over propofol that has been drawn up into a syringe from your morning list to your afternoon list?	No (0)			Yes (3)
12	Within what time frame should propofol be administered after drawing it up into a syringe?	6 h (0)			12 h/24 h (3)
13	In the ICU, what is the maximum duration of a propofol infusion after which the giving set should be changed?	12 h (0)			24 h/36 h/ 48 h (3)
			Maximum possible score = 39		

Notes: Numbers in parentheses denote the number of points allotted to the corresponding answers.
ICU = intensive care unit.

Appendix C: **Participant replies to *'In what way have you changed your practice in the handling of propofol?'***

Replies by the 62/185 participants who had studied the SASA Guidelines and stated that they had changed their practices to the question *'In what way have you changed your practice in the handling of propofol?'*

(1) Use within 6 hours, no sharing.
(2) 1 patient 1 bottle/limit time propofol left standing discard if concerned.
(3) Although this survey is testing an important aspect, as a consultant in a large state hospital I am privy to the practices of many anaesthetists. I believe the problem of contaminated drugs is much much bigger than merely drawing up the drug and capping the needle. The issue of actually administering the drug is much bigger. Who actually cleans the clave port before injecting. Often the syringes are just left uncapped. Also three-way taps are left uncapped etc. etc. ... I keep reminding people to inject the drug in a manner that they would like for themselves.
(4) Aware of infection control concerns specific to propofol ... wipe ampoule....
(5) Changing syringes.
(6) Discard left over propofol after 6 hours.
(7) Discard leftover propofol.
(8) Do not use single vial for more than one patient.
(9) Do not use left over propofol for the next patient.
(10) Duration after drawing up a syringe to discard it.
(11) Far stricter in sterility and handling ampoules.
(12) I am more conscious of the risk of infection, and I never use propofol after 6 hours of drawing it up.
(13) I do not draw up propofol in advance.
(14) I do not share multi-dose vials between patients.
(15) I don't reuse the same syringe for different patients with infusions.
(16) I don't use the same vial on multiple patients and I draw up the propofol as I am about to use it.
(17) I now never use the same syringe for multiple patients and I no longer do amoule sharing.
(18) I use a more sterile technique like wiping the ampoule with alcohol and letting it dry.
(19) It must be used as soon as possible after opening.
(20) Maintain proper sterility.
(21) More care regarding septic risk.
(22) More careful.
(23) More conscious of contamination.
(24) More stringent changing of needles and syringes for same patient, always changed between patients previously.
(25) Never share.
(26) Never share, use immediately following drawing into the syringe.
(27) New needle and syringe.
(28) New syringes. No multiple uses of 50 ml vial.
(29) No more sharing of ampoules between patients, shorter time allowed before discarding leftovers, use new needles every time, only re-use the same 50 ml syringe for the same patient if nothing else available.
(30) No sharing.
(31) No Sharing; New syringes and needle; No carry-over.
(32) No vial sharing.
(33) Not drawing up early before case.
(34) Not sharing ampoules any more.
(35) Not sharing and not using syringes between pt. and not using left open ampoules.
(36) Not to dilute propofol.
(37) One patient only per vial/ampoule.
(38) Opening practices.
(39) Reduce time frame for administration.
(40) Safer.

(41) Single use, aseptic technique.
(42) Single patient per vial.
(43) Single patient, single syringe.
(44) Single use and draw up propofol just prior to administration.
(45) Stopped using single vial for multiple patients.
(46) Strict time limits to use propofol.
(47) Stricter asepsis.
(48) Swipe ampoules before use. Never put syringe in pocket any more.
(49) Time to changing giving set.
(50) To adhere to Infection Control Practices.
(51) Use as soon as possible.
(52) Use new propofol per patient.
(53) Use within 6 hours.
(54) Use within 4 hours after opening the ampoule. Use webcol to clean the neck of the ampoule.
(55) Use within 6 hours of drawing up into syringe.
(56) Using new syringes and not carrying propofol over to another patient or use after 6 hours.
(57) Using new needles and syringes even when drawing propofol up for the same patient. Using one vial per patient i.e. not sharing. Not mixing drugs in the same syringe.
(58) Vial opening and preparation.
(59) Wipe.
(60) Wiping the amp before breaking it.
(61) Wiping with webcol.
(62) Working more sterile.