

Alcohol Caps or Alcohol Swabs With and Without Chlorhexidine: An *In Vitro* Study of 648 Episodes of Intravenous Device Needleless Connector Decontamination

The incidence of central venous access device (CVAD)-associated bloodstream infection (CABSI) has been reported to be as high as 21%.¹ Inadequate needleless connector decontamination can result in microbial contamination of the CVAD internal lumen, resulting in device colonization and CABSI.² Guidelines vary in recommendations for antiseptic type and duration of application to needleless connectors.³ Scrubbing needleless connectors with chlorhexidine in alcohol swabs is recommended by some guidelines to prevent infection.^{2,4} However, lack of consistent needleless connector decontamination prior to use may negate the effectiveness of this approach. There is a need to define the most effective needleless connector decontamination techniques, including the antiseptic type and the duration of application. In this study, we investigated the comparative efficacy of 3 needleless connector decontamination methods and 3 connector types with different durations of application to prevent microbial contamination.

In this microbial *in vitro* study, we used the following types of needleless connectors: SmartSite (CareFusion, Becton Dickinson, Franklin Lakes, NJ; $n = 216$), Safeflow (B. Braun, Melsungen, Germany; $n = 216$), and MaxPlus Clear (CareFusion, Becton Dickinson; $n = 216$). A total of 648 connector decontamination procedures were performed for this study; 3 experiments per connector type were performed to ensure valid results. *Staphylococcus aureus*, *S. epidermidis*, *Pseudomonas aeruginosa*, and *Candida albicans* were used as test organisms. For half of the experiments ($n = 324$ connectors), needleless connectors were pre-coated with sterile human serum, which remained *in situ* for 1 hour under static conditions in a class II biological safety cabinet, prior to exposure to microbial inoculum. Human serum (Sigma-Aldrich) was filter sterilized ($0.2 \mu\text{m}$) before use. The overnight broth culture was adjusted to an OD_{600} (optical density of a sample measured at 600 nm) of 0.12 and diluted to 1:200 (final concentration 0.5×10^6) before application to each needleless connector. These parameters were chosen as a possible clinically reflective levels rather higher concentrations used in other studies.⁵ Following air drying, the inoculated needleless connectors were disinfected with 1 of the following 3 items: 70% isopropyl alcohol swabs (IPA swabs; Reynard Health Supplies, Havelock North, Hawkes Bay, New Zealand); 70% isopropyl alcohol-impregnated caps (AICs; Excelsior Medical, Neptune City, NJ); or chlorhexidine gluconate swabs with 2% CHG w/v + 70% isopropanol v/v (CHG swabs; 3M, London, Ontario, Canada). For decontamination using the swabs, scrubbing

consisted of back-and-forth twisting motion for 5, 15, or 30 seconds; the AICs were used for 5 minutes. After decontamination, needleless connectors were allowed to dry for 30 seconds, flushed with media, and cultured. Prior to these experiments, a negative control (no microbial contamination) and a positive control (no decontamination after microbial contamination) were studied for each needleless connector type. In addition, 3 positive and 3 negative controls were included for each connector and for contamination by each microorganism. The positive control was used to determine microbial recovery through each type of needleless connector if no decontamination occurred. These data were used to calculate the ratio of reduction in microorganisms passing through decontaminated needleless connectors, and we divided the colony count per decontamination group by the baseline colony count from the positive controls. Mean and standard deviations were calculated; t tests were used to test differences between groups, and $P < .05$ was considered statistically significant. Differences between needleless connector types and organisms detected were negligible; therefore, results were pooled per decontamination group.

CHG swabs resulted in a greater reduction of organisms than the IPA swabs: for CHG30 (ie, a CHG wipe for 30 second) vs IPA30 (an IPA wipe for 30 seconds), $t(70) = 74.32$ ($P < .01$) (Figure 1a). The AICs cleared less organisms than the CHG swabs: for CHG30 vs AIC, $t(70) = 28.25$ ($P < .01$). However, the AICs cleared more organisms than the IPA swabs: for AIC vs IPA30 swabs, $t(70) = 5.01$ ($P < .01$). On average, this result equated to 4.03 log passing through positive controls, compared to experimental pass-through logs, as follows: 0.89 for IPA5 (ratio reduction [RR], 0.78), 0.64 for IPA15 (RR, 0.84), 0.54 for IPA30 (RR, 0.87), 0.38 for IC (RR, 0.91), 0.12 for CHG5 (RR, 0.97), 0.02 for CHG15 (RR, 0.995), and 0.01 for CHG30 (RR, 0.998).

In the presence of serum exposure, most comparisons of microorganism reductions remained statistically significant (Figure 1b). However, less reduction occurred in percentage colony counts without serum exposure: for CHG30 vs IPA30, $t(70) = 35.14$ ($P < .01$); for CHG30 vs AIC, $t(70) = 36.09$ ($P < .01$); and for AIC vs IPA30 swab, $t(70) = 1.57$ ($P = 0.12$). On average, 2.81 log passed through positive controls, compared to the following experimental pass-through logs: 1.19 for IPA5 (RR, 0.58); 0.75 for IPA15 (RR, 0.73); 0.55 for IPA30 (RR, 0.80); 0.49 for AIC (RR, 0.83); 0.13 for CHG5 (RR, 0.95); 0.13 for CHG15 (RR, 0.95); and 0.03 for CHG30 (RR, 0.99).

A 5-second disinfection of the needleless connector with IPA swab is the standard practice at our institution. Like previous research,^{6–8} the results of this study suggest that it is an inadequate method for this purpose. Regarding cost, the change to CHG swabs would not be prohibitive; the 2016 purchase costs from Queensland Health were USD 0.022 (AUD 0.03) per unit for IPA swabs; USD 0.072 (AUD 0.10) per unit for CHG swabs; and USD 0.217 (AUD 0.30) per unit for

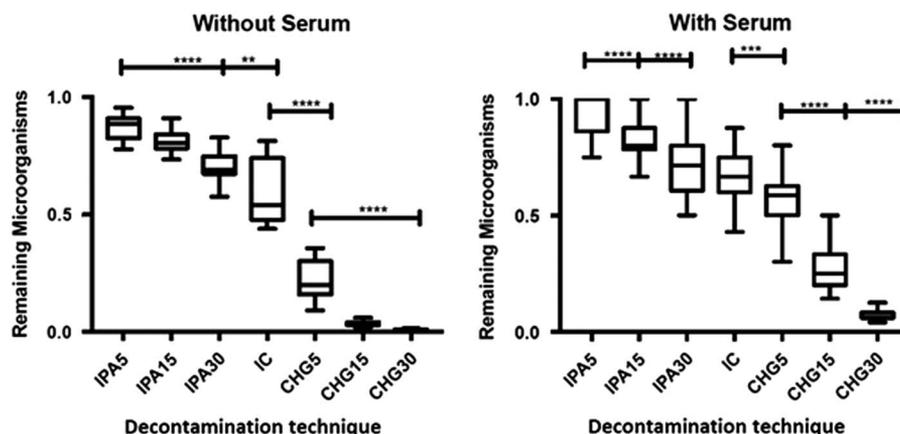


FIGURE 1a and 1b. Percentage of overall organisms remaining following decontamination of the needleless connector. Abbreviations: IPA, 70% isopropyl alcohol with 5-, 15-, and 30-second decontamination; CHG, chlorhexidine gluconate in 70% isopropyl alcohol with 5-, 15-, and 30-second decontamination; IC, 70% isopropyl alcohol impregnated cap. $**P = .0021$; $***P = .0002$; $****P < .0001$. The higher the percentages, the higher the amount of microorganisms remaining on the needleless connector.

AICs. These slightly higher prices would be offset if CABS risk from poor decontamination decreased. AICs with 5-minute exposure demonstrated similar performance as the IPA swab for 30 seconds. CHG swabs clearly outperformed the IPA swabs and the AICs with or without human serum exposure. However, once exposed to human serum, the organism reduction was reduced by $>50\%$, even with the use of CHG swabs. Because CVADs are regularly used to draw blood and administer blood transfusions through needleless connectors, these results suggest that needleless connectors are more difficult to decontaminate if they are not discarded after blood draws or transfusions.

Our data suggest that the ideal method of needleless-connector decontamination is 30 seconds with CHG swabs, although even 5-second CHG swabbing outperformed other methods. However, poor compliance with active decontamination method may negate the effectiveness of CHG swabbing. CHG swabbing also leaves a residue on the external surface of the needleless connector, and it is unclear whether this residue has ongoing antimicrobial benefit, degrades the connector material, or even leads to CHG injection into the bloodstream. Further research is needed to elucidate these issues.

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