Evaluation of the efficacy of antibacterial medical gloves in the ICU setting

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SUMMARY
Background: Inappropriate use of medical gloves may support microbial transmission. New strategies could increase the safety of medical gloves without the risk of patient and surface contamination.

Aim: To compare the efficacy of synthetic antibacterial nitrile medical gloves coated with polyhexamethylen-biquanid hydrochloride (PHMB) on the external surface with identical non-antibacterial medical gloves in reducing glove contamination after common patient care measures in an intensive care unit (ICU) setting.

Methods: ICU staff wore either standard or antibacterial gloves during patient care activities. The number of bacteria on gloves was measured semi-quantitatively immediately after the performance of four clinical activities.

Findings: There was a significant difference in mean bacterial growth [colony-forming units (cfu)] between control gloves and antibacterial gloves [60 [standard deviation (SD) 23] vs 16 (SD 23) cfu/glove imprint, \( P < 0.001 \)]. In three of the four clinical activities (intravenous fluid handling, oral toilet and physiotherapy), the antibacterial gloves had significantly less bacterial contamination compared with the control gloves (\( P = 0.011 \) and \(< 0.001 \), respectively). Although antibacterial gloves showed lower bacterial contamination after changing linen compared with control gloves, the difference was not significant (\( P = 0.311 \)).

Conclusion: This study showed that use of antibacterial medical gloves significantly reduced bacterial contamination after typical patient care activities in 57% of the investigated clinical activities (\( P < 0.01 \)). The use of antibacterial medical gloves may support reduction of cross-contamination in the ICU setting.

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Introduction

The World Health Organization (WHO) recommends that medical gloves should be worn during all patient care activities that may involve exposure to blood and other body fluids, including contact with mucous membranes and wounds during contact precautions, and during outbreak situations. If used...
correctly as an adjunct with hand hygiene measures, medical gloves will prevent contamination of healthcare workers’ hands, and may decrease the risk of horizontal transmission of potentially pathogenic micro-organisms.1–3

However, incorrect use of contaminated gloves due to inappropriate techniques for donning and removal may support transmission of micro-organisms. Therefore, in critical situations, WHO recommends that gloves should be removed and hand hygiene should be performed in circumstances when gloves are visibly damaged or suspected to be damaged, when contact with body fluids has occurred, and when contact with contaminated body sites on a patient has ended. While these recommendations will prevent unintended contamination of surrounding surfaces, it needs to be acknowledged that compliance is extremely difficult, particularly in intensive care units (ICUs) where the workload and the number of patient contacts are high. Indeed, inappropriate use of gloves is common in all healthcare facilities worldwide, and medical staff often fail to remove gloves between patients or between contacts with various sites on a single patient, thus potentially facilitating the spread of micro-organisms.1,3,4

Antibacterial medical gloves are a new concept that may prevent cross-infection through reduction of surface and patient contamination. Recently, an in-vitro study was conducted on the antibacterial efficacy of a novel, non-sterile powder-free nitrile-based medical glove coated with the active ingredient polyhexamethylene-biguand hydrochloride (PHMB) on its outside surface.3 These gloves are intended to be worn by medical staff during patient examination and patient care to prevent cross-contamination of micro-organisms between clinically relevant contaminated surfaces found in healthcare settings, patients and other individuals. The in-vitro experimental study1 demonstrated that the number of bacteria recovered from initially sterile stainless steel test surfaces after contact with standardized contaminated gloves was significantly lower after contact with antibacterial-coated medical gloves compared with identical non-antibacterial control gloves. The results of this in-vitro study encouraged the present authors to explore the potential of this concept in practice by using antibacterial medical gloves in an ICU setting.

Methods

This study was designed to compare the efficacy of synthetic antibacterial nitrile medical gloves with PHMB coating on the external surface (Gammex Nitrile Antibacterial, Ansell Ltd., Canada) with non-antibacterial control gloves based on the same nitrile formulation (Micro-Touch Denta-Glove White Nitrile, Ansell Ltd., Australia) in reducing glove contamination after common patient care measures in an ICU setting. All gloves were manufactured in Malaysia under the same conditions from the same nitrile latex formulation at the same factory. The study was approved by the Medical Ethics Committee of the University Malaya Medical Centre (EC/IRB Reference No.: 975.23).

Study setting

This study was conducted at a 14-bed, adult, mixed surgical and medical ICU in the University Malaya Medical Centre over two consecutive morning shifts which were one week apart. For each shift, ICU staff wore either synthetic nitrite medical gloves with PHMB coating on the external surface or identical non-antibacterial gloves. In total, 30 pairs of gloves were used per shift (antibacterial gloves: N = 15; non-antibacterial gloves: N = 15). Users and the principal investigator were blinded to the glove type, which was only identifiable by the letters ‘A’ or ‘B’ on the plain cardboard dispenser glove packs. In order to prevent carryover of PHMB to surrounding surfaces, staff used 15 pairs of Glove A (non-antibacterial gloves) first, followed by 15 pairs of Glove B (antibacterial gloves).

Four clinically relevant activities were investigated in this study under the same conditions as they would normally be conducted in the ICU environment. These were: (a) removing and replacing bed linen and turning the patient; (b) oral toilet and/or oral suction; (c) drawing blood and administration of medication or fluid through intravenous central lines; and (d) physiotherapy.

Microbiological sampling and specimen processing

Immediately after use, and before touching any other surface, participants gently pressed the gloved fingertips and thumb of their dominant hand on to tryptic soy agar plates (Merck KGaA, Darmstadt, Germany) with neutralizer (polysorbate 80 5 g/L; lecithin 0.7 g/L). After touching the agar plates with all four gloved fingers and thumb, participants removed the gloves from their hands and disposed of them. The duration of wear of each glove pair was measured and recorded.

All plates were incubated at a mean temperature of 37 °C [standard deviation (SD) 2 °C] under aerobic conditions for 24–48 h. Bacterial numbers [colony-forming units (cfu)/glove imprint], characteristic colony morphology and Gram stain results were noted. Further tests were performed by culturing on to Columbia agar containing 5% horse blood and MacConkey agar (Oxoid Ltd., Basingstoke, UK), followed by standard biochemical and microbiological tests to confirm the identity of the organisms yielded. For the purposes of this study, a total colony count of 1–10 cfu/glove imprint was considered as scant growth (+), 11–25 cfu/glove imprint was considered as moderate growth (+++), and >25 cfu/glove imprint was considered as heavy growth (+++).

Statistical analysis

Data were analysed to determine statistical differences between heavy growth (>25 total cfu/glove imprint), scanty to moderate growth, and no growth from both types of gloves. Analyses were performed using Statistical Package for the Social Sciences Version 17.0 for Windows (IBM Corp., Armonk, NY, USA). Univariate comparisons for continuous variables and categorical variables were computed using Student’s t-test, Chi-squared test or Fisher’s exact test, where appropriate. Statistical significance was set as P < 0.05.

Results

The mean wear times of non-antibacterial control gloves and antibacterial gloves were 10.3 and 9.8 min, respectively (P < 0.05). After patient care, 100% (30/30) of the non-antibacterial control gloves had positive imprint cultures of
any recoverable bacteria numbers compared with 43% (13/30) of the antibacterial gloves ($P < 0.001$). Heavy growth was seen in 90% (27/30) of the non-antibacterial control gloves and 13% (4/30) of the antibacterial gloves ($P < 0.001$, Figure 1).

Of the four patient care activities investigated, only ‘replacing linen/turning patient’ showed no significant difference in the mean number of cfu/glove imprint between the antibacterial gloves [44 (SD 36)] and non-antibacterial control gloves [69 (SD 12), $P = 0.311$]. All other activities showed significant differences in favour of the antibacterial gloves (Table I), with a significant difference in the overall mean cfu growth/glove imprint between the control gloves and antibacterial gloves [60 (SD 23) vs 16 (SD 23), $P < 0.001$].

In the antibacterial glove group, three out of 13 samples grew Gram-positive (Gr+) bacteria alone, of which one sample had heavy bacterial growth of >25 cfu/glove imprint. Another three of these 13 samples grew Gram-negative (Gr-) bacteria alone, but none showed heavy bacterial growth. Both Gr- and Gr+ bacteria were found in seven out of 13 samples, with three of these six samples having heavy bacterial growth. In total, the antibacterial glove group showed heavy bacterial growth in four samples: one sample with heavy Gr+ growth and three samples with mixed Gr+ and Gr- growth.

In the non-antibacterial control glove group, 17 out of 30 samples showed growth of Gr+ bacteria alone, of which 15 samples had heavy growth. None of the positive cultures in the non-antibacterial control glove group grew Gr- bacteria alone. Mixed growth of Gr- and Gr+ bacteria was found in 13 out of 30 samples, with 12 of these 13 samples having heavy bacterial growth. Significant differences were found between the two groups when comparing samples with heavy growth of Gr+ bacteria alone ($P = 0.02$) or mixed growth of Gr- and Gr+ bacteria ($P = 0.03$).

Discussion

In 1996, the US Hospital Infection Control Practices Advisory Committee published its ‘Guideline for isolation precautions in hospitals’. This guideline adjusted the previous concept of isolation precautions, and introduced the concept of ‘standard precautions’ which mandates that all healthcare workers who come into contact with body fluids should wear gloves. However, in practice, it is largely ignored that this recommendation does not advocate the use of gloves for all clinical procedures; instead, healthcare workers are advised to assess the risk in each clinical situation. However, frequent and often incorrect glove usage is increasingly observed without adequate risk assessment.

Inappropriate use of medical gloves may support microbial transmission. A study conducted at a French university hospital including three ICUs and two medical wards revealed that microbial transmission may have occurred in 18% of all patient contacts because used gloves were not removed before performing critical care activities. Failure to remove contaminated gloves was identified as a major factor with a high risk of microbial transmission. Therefore, it was correctly highlighted that behavioural interventions are required to reduce glove misuse in clinical practice.
While information and education on the correct use of medical gloves is the most prudent solution to this matter, it may well be the most difficult to achieve. Therefore, there is a need to explore new strategies that may make the use of medical gloves safer by reducing the risk of patient and surface contamination. Such strategies include the use of gloves with altered surface materials that are able to decrease bacterial attachment, or antibacterial-coated gloves.5,11,12

This study showed that synthetic antibacterial nitrile medical gloves with PHMB coating on the external surface were able to prevent bacterial contamination of gloves after typical patient care activities in 57% of investigated clinical activities, and that the mean number of bacteria retrieved from antibacterial gloves with positive growth (13/30) was significantly lower compared with non-antibacterial control gloves (1.2 vs 3.2 cfu/glove imprint, P = 0.002).

This study is limited by the fact that it did not investigate whether or not bacteria transferred from a patient to the gloves could further be transferred to another patient or a critical surface adjacent to ICU patients. While the transfer of micro-organisms from a test surface back to ICU patients is considered to be unethical, transfer to other surfaces has been demonstrated previously in controlled experimental studies.13

These studies further revealed an interesting phenomenon; contrary to common belief, it was shown that bacterial transfer rates were lower when the inoculum size on the source was greater, compared with when the inoculum size on the source was smaller. This negative linear association may also explain why this study found that the only patient care activity with no significant difference in cfu counts on antibacterial or non-antibacterial control gloves was replacing bed linen and turning ICU patients. Hence, the different results for certain activities may be the result of differing initial inoculum size.13

However, as the number of bacteria on the initial source was not measured, it is not possible to ascertain this hypothesis. Furthermore, the possibility that surface topography and/or the presence or absence of moisture on gloves may have affected transfer rates cannot be excluded.12 Secondly, the selection of intervention and test gloves used by participants was random, only controlled for an equal number of clinical activities per glove. This measure allowed completion of the test matrix for glove allocation based on the category of the clinical activities. However, this design did not allow further stratification, and evenly distributed allocation of test and intervention gloves to the same participant for the same clinical activities. Therefore, it cannot be ascertained that participants used the control and intervention gloves on the same clinical activity, ruling out possible individual differences. While this aspect may also limit the study, ruling out PHMB carryover and securing an equal distribution of clinical activities was more important than controlling for theoretical individual differences in glove contamination during clinical work.

Pertaining to the bacteria spectrum found on antibacterial gloves, the higher numbers of typical skin micro-organisms were not surprising. However, the presence of 5 cfu Pseudomonas aeruginosa and 4 cfu Acinetobacter baumannii on single gloves warrants cautious attention, as this may be the result of a potential selection phenomenon. The in-vitro antibacterial efficacy of PHMB has received considerable research attention,14 and has been found to be low risk for contact or type I sensitization.15,16 Due to an unspecific, strong interaction with negatively charged phospholipids, PHMB has a broad antimicrobial spectrum, covering Gram+ and Gram- bacteria, intracellular bacteria (e.g. chlamydia, mycoplasma) and fungi (e.g. Candida spp. and Aspergillus spp.). However, some naturally unsusceptible bacteria are known, particularly Pseudomonas spp. or Acinetobacter spp., but also other Gram- non-fermenting bacilli such as Alcaligenes spp. 14

In conclusion, the use of antibacterial medical gloves may be a new strategy to prevent or reduce cross-contamination and hence indirect transmission of micro-organisms in ICU settings. However, possible selection of bacteria such as Pseudomonas spp. or Acinetobacter spp. must be observed carefully and studied in more detail.

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Conflict of interest statement

VR, MKB, YY, WKK and OA have no conflicts of interest to declare. OA has received travel compensation and speaker’s honoraria in the past from B. Braun Melsungen AG, Ethicon, Schulke and Paul Hartmann AG. OA is a medical advisory board member of Hutchinson santé and Mölnlycke Healthcare, and serves as a part-time consultant for Gerson-Lehman Group and Quantum Management Services. The content of this paper and the conclusions reached are the personal opinions of the authors, based on scientific and professional grounds.

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