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Hospital infection control in 2012: new solutions for old and resurgent problems

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Routes of transmission for nosocomial pathogens are complex including the hands of healthcare personnel (HCP), contaminated surfaces and inanimate objects, and, in some circumstances, air and other routes.[1] The relative importance of each transmission route is difficult to determine and will vary with pathogen and scenario. For example, it is likely that *Clostridium difficile* transmission is more dependent on contaminated environmental surfaces than other pathogens due to its ability to form resilient endospores that are shed in high numbers during episodes of diarrhoea.[1-3] Thus, in order to interrupt transmission of nosocomial pathogens, infection prevention and control interventions are aimed at containing affected individuals and reducing the degree of shedding, ensuring that compliance with the appropriate hand hygiene protocols are observed by HCP and effectively disinfecting contaminated surfaces and equipment.[1] This brief review provides an overview of recently published literature relating to reducing or containing the shedding of pathogens from affected patients, and advances in hospital disinfection and hand hygiene.

Reducing shedding – 'source control'

A relatively recent innovation to reduce the spread of nosocomial pathogens is the use of topical antiseptic agents – typically chlorhexidine gluconate – to reduce the microbial load on patients' skin. This is often referred to as "source control".[4] A Japanese study evaluated the effectiveness and safety of topical chlorhexidine gluconate (CHG).[5] The study found that CHG is an effective biocide that is well tolerated by patients. Whilst "source control" has been shown to reduce transmission of a range of pathogens including MRSA and VRE, CHG is not effective against *C. difficile* spores.[4,6-8] However, surprising, a recent study from a US hospital found that regular bathing with CHG reduced the incidence of *C. difficile*.[9] It seems likely that whilst the CHG is not effective at killing the *C. difficile* spores, the mechanical action of bathing the patient removes the spores to the extent that transmission is reduced.

However, there is a risk that the widespread use of CHG could select for microbes with reduced CHG susceptibility. Indeed, a recent study from London found that the widespread use of CHG selected for an MRSA clone with reduced CHG susceptibility, and that this may have had a selective advantage for the success of this clone relative to others.[10]

Reducing shedding – improved diagnosis

One of the cornerstones of effective infection prevention and control is the identification of those patients who are infected or colonised with epidemiologically important organisms. Improvements in the diagnosis of infectious diseases also helps in providing prompt, appropriate therapy, which will serve to reduce morbidity and mortality for individual patients and reduce the disease burden for the susceptible population. The most common method used to diagnose *Clostridium difficile* infection (CDI) in most parts of Europe was an enzyme immunoassay (EIA), which works by detecting the *C. difficile* toxin.[11] However, recent data indicate that EIA tests

have a very poor diagnostic sensitivity in the order of 50%, meaning that for every case of CDI correctly identified, a case would be missed.[12,13] More accurate diagnostic tests are available, often combining a preliminary screening test for glutamate dehydrogenase (GDH), which has a high sensitivity but a low specificity, followed by a very sensitive but more expensive PCR to provide an overall sensitivity of >95%.[13] The accurate diagnosis of CDI means more prompt, appropriate treatment and will help to reduce transmission. However, increased case ascertainment has proved problematic in the UK where each hospital is given a target by the Government for the number of permissible CDI cases.

Another development in the effective identification of pathogens has been forced by the increasing numbers of resistant Gram-negative bacteria being reported worldwide.[14,15] The European Centre of Disease Control (ECDC) has recently recommended that 'Active surveillance by rectal screening of any patient transferred across borders into a healthcare facility in another country is strongly recommended by the group of experts.'[16] This is likely to facilitate improved control of these pathogens, but will also provide an increased requirement for single rooms in which to cohort affected patients.

Contain shedding – the need for more single rooms

There is evidence that placing patients in shared rooms increases their chance of healthcare-associated infection (HCAI),[17,18] an increase in single occupancy rooms reduces HCAI,[19-22] patients in single rooms are more satisfied with their care,[23,24] patients respond well to the privacy and dignity[25,26] afforded by single occupancy rooms and that hand hygiene compliance is significantly improved for patients in single rooms.[17] Thus, improving the number of single occupancy rooms is an attractive option. Whilst this can be achieved through permanent conversion of multi-occupancy areas, this has high capital costs and risks reducing the number of available beds. An alternative approach is to temporarily segregate multi-occupancy clinical areas into individual 'pods'. A UK Department of Health funded study evaluated the impact of several different products to achieve this purpose and found that hand hygiene compliance increased from 57% to 73% for patients treated in temporary side rooms ($p<0.05$).[17] Also, staff and patient acceptability was generally good, and cost savings of £43,040 (￥5.5m) per annum were identified through accelerated ICU discharge.[17] Further evaluations of options to segregate multi-occupancy clinical areas into individual pods are warranted.

Hand hygiene

There is a complex interplay between the hands of HCP, patients and their inanimate environment.[1] A recent article evaluated the acquisition of *Clostiridium difficile* spores on the gloved hands of HCP following contact with environmental surfaces and patients.[27] There was no significant difference between the rate of contamination of HCP hands when touching the patient as compared with touching environmental surfaces (50% for both). This study follows other that have examined the proportion of contacts with either patients or surfaces that result in HCP hand contamination. These studies have shown that the risk of acquiring hand contamination when touching a patient or a surface is approximately equal for MRSA and VRE.[28,29] It seems likely that a substantial proportion of transmission between patients occurs indirectly through contact with environmental surfaces. There has been much discussion around whether to focus on improving environmental cleaning and disinfection or compliance with hand hygiene. These studies demonstrate that there is a need to improve both in order to reduce contamination of HCP hands and subsequent transmission.

Environment cleaning and disinfection

Biofilms

Biofilms are known to be important in several areas of medicine including indwelling medical devices and endoscope tubing, usually associated with surface-water interfaces.[30] However, it was unclear whether biofilms formed form on dry hospital surface. A recent Australian study

'destructively sampled' several hospital surfaces after cleaning and disinfection using bleach (i.e. cut the materials out of the hospital environment and took them to the lab for analysis).[31] Scanning electron microscopy was used to examine the surfaces for biofilms, which were identified on 5/6 surfaces: a curtain, a blind cord, a plastic door, a wash basin and a reagent bucket. Furthermore, MRSA was identified in the biofilm on three of the surfaces.

Could it be that we have missed or underestimated the importance of biofilms on dry hospital surfaces?[30] Biofilms could explain why vegetative bacteria can survive on dry hospital surfaces for so long, be part of reason why they are so difficult to remove or inactivate using disinfectants (bacteria in biofilms can be 1000x more difficult to kill than corresponding planktonic bacteria) and explain to some degree the difficulty in recovering environmental pathogens by surface sampling.

Biofilms are clearly not the only reason for failures in hospital disinfection given the difficulty in achieving adequate distribution and contact time using manual methods, but these findings may have implications for infection control practices within hospitals and on the choice of the appropriate disinfectants used to decontaminate surfaces.

Hydrogen peroxide vapour (HPV) room disinfection

Two studies published in 2012 provide evidence that the regular use of HPV disinfection for selected patient rooms can reduce the transmission of nosocomial pathogens. A cohort study by Passaretti *et al.*[32] found that patients admitted to rooms vacated by patients with multidrug resistant organisms (MDROs) and disinfected using HPV were 64% less likely to acquire MDROs than patients admitted to such rooms disinfected using standard methods. Previous studies have shown that patients admitted to rooms where the previous occupant has was infected or colonised with an MDRO are more likely to acquire that MDRO due to residual contamination.[1,33,34] Thus, it seems that HPV decontamination successfully mitigated the risk from the prior room occupant.

A before-after study by Manian *et al*. showed that the introduction of HPV combined with enhancements in conventional disinfection significantly reduced the hospital wide incidence of *C. difficile*.[35] These studies provide further evidence that HPV should be considered for the terminal disinfection of rooms and other clinical areas used to care for patients with certain environmentally-associated pathogens.

"No-touch" automated room disinfection systems

A recent review summarises the evidence surrounding the use of "no-touch" automated room disinfection (NTD) systems in healthcare settings.[36] Conventional disinfection methods can be limited by reliance on the operator to ensure appropriate selection, formulation, distribution and contact time of the agent. These problems can be reduced by the use of NTD systems. A number of NTD systems have emerged, which remove or reduce reliance on the operator to ensure distribution, contact time and process repeatability, and aim to improve the level of disinfection and thus mitigate the increased risk from the prior room occupant. Available NTD systems include hydrogen peroxide vapour systems, aerosolised hydrogen peroxide (aHP) and ultraviolet (UV) radiation. These systems have important differences in their active agent, delivery mechanism, efficacy, process time and ease of use. Typically, there is a trade-off between time and effectiveness amongst NTD systems. The choice of NTD system should be influenced by the intended application, the evidence base for effectiveness, practicalities of implementation and cost constraints. NTD systems are gaining acceptance as a useful tool for infection prevention and control.

A recently published study compared an HPV system (Bioquell) with an aerosolised hydrogen peroxide (aHP) system (ASP Glosair).[37] The independent study was performed by researchers at St. Georges' Hospital. Testing was performed in a $50m^3$ room with a $13m^3$ anteroom, representing a single occupancy room with bathroom. For both systems it was found that rooms must be sealed to prevent leakage and room re-entry must be led by a hand held sensor to ensure safety. HPV generally achieved a 6-log

reduction of spore BIs and in-house prepared test discs inoculated with MRSA, *Clostridium difficile* and *Acineotbacter baumannii*, whereas aHP generally achieved a 4-log reduction or less. The aHP system had reduced efficacy against the catalase-positive *A. baumannii* with a <2-log reductions in the majority of room locations. HPV was able to penetrate soiling more effectively than aHP and uneven distribution of the active agent within the enclosure was evident for aHP but not for HPV.

It is difficult to produce a laboratory challenge that is truly representative of field conditions, but the authors used several different ways to measure the efficacy of the products, concluding that 'the HPV system was safer to operate, slightly faster and achieved a greater level of biological inactivation than the aHP system.'[37]

Conclusion

The spread of pathogens in healthcare settings is multifaceted. The use of topical disinfectants for 'source control, improving the accuracy of diagnostics and the coverage of screening programmes and an increase in the number of single-occupancy beds can help to reduce and contain the shedding of pathogens. Continued emphasis on improving compliance with appropriate hand hygiene protocols and hospital cleaning and disinfection can help to reduce the acquisition of pathogens on the hands of HCPs and prevent spread to susceptible patients. Finally, consideration should be given to the use of NTD systems to improve terminal disinfection in some scenarios. Given the complexity in terms of routes of transmission involving patients, the hands of HCP, environmental surfaces and air, multiple strategies should be taken to maximize patient safety.

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