Literature Review and Recommendations
EMS Equipment and Transport Vehicle Cleaning and Disinfection
EMS Bureau Protocol Review Steering Committee

Background

Healthcare associated infections (HAIs) affect millions of patients annually (World Health Organization. Guidelines on Hand Hygiene in Healthcare. Geneva: WHO Press; 2009). Hand hygiene compliance of clinical staff has been identified by numerous studies as a major contributing factor to HAIs around the world. Infection control and hand hygiene in the prehospital environment can also contribute to patient harm and spread of infections. Emergency medical services (EMS) practitioners are not monitored as closely as hospital personnel in terms of hand hygiene training and compliance. Their ever-changing work environment is less favorable to traditional hospital-based aseptic techniques and education.

Ambulances are the front line of medical care, and the risk of exposure to patients with known or unknown infectious diseases or pathogens is high. The importance of understanding the principles of infection prevention and control and reducing disease transmission in EMS is often misunderstood and can lead to error or unsafe practice. Routine cleaning and disinfection and following safe practices are often overlooked or not performed simply because "we don't have time" or it is not recognized as being necessary. Therefore, many different infection control procedures are being employed to prevent ambulances from possibly transmitting, either to medical personnel or patients, or relatives of patients. Although many hospital-based infection control programs are being used at present, ambulance disinfection has not been widely emphasized upon as an important part of public health administration.

The relation between disinfection and cleaning procedures along with the use, and effect of fumigation of ambulances to minimize further spread of infections to patients and medical personnel needs to be closely investigated. Published studies focusing on transmission to surfaces and medical equipment in healthcare facilities and ambulances have proven that contamination of the environment has likely contributed to the spread of pathogens.

With new regulations regarding Medicare and Medicaid reimbursement, the Center for Medicare and Medicaid Services is monitoring readmission rates. Hospitals have a financial motive to start looking elsewhere for the culprit when a patient returns with an infection. Hospitals are now paying more attention to doing compliance monitoring to assure that the patient did not get an infection at their facility. The same expectation for quality of care extends to EMS.

Question

What are the implications of not following infection control procedures in hand washing, cleaning, and disinfecting environmental surfaces and patient care equipment in preventing the spread of infections in prehospital settings?

Methods

NMDOH digital library; keywords searched: pre-hospital, decontamination, ambulance, infection transmission, disinfection, MRSA, ambulance cleaning procedures, fumigation

Search engine used: PubMed, Clinical Trials, Cochrane Library

Review process: A review of the literature was conducted using two electronic medical literature databases. Medical subject headings, keywords and a pre-hospital search filter were used to yield relevant literature. Also screened were reference lists of included trials and relevant reviews.

Number of articles reviewed: Twenty

Number of articles deemed to be relevant: Twelve

Types of Articles: a prospective, prevalence study and survey, a designed survey about hand hygiene practices, another survey distributed to various national EMS organizations through e-mail used descriptive statistics to calculate survey items and analysis of variance to test differences in means between subgroups of exposure types, a cross-sectional study of 106 air samples collected from 30 ambulances before patient services and 212 air samples collected during patient services to assess the bacterial and fungal counts at the two time points, a study which collected 226 surface swab samples from medical instrument surfaces and the surrounding areas before and after ambulance runs

Articles cited to draw conclusions and formulate recommendations: Eight

Results

Teter, Millin and Bissell conducted a study to determine the current state of hand hygiene practices among EMS providers and to provide recommendations for improving practices in the emergency health services. This study was a prospective, observational prevalence study and survey, conducted over a 2-month period. Participants were selected from visits to three selected hospital emergency departments in the mid-Atlantic region. There were two data components to the study: a participant survey and hand swabs for pathogenic cultures. This study demonstrated that EMS providers are potential vectors of microorganisms if proper hand hygiene is not performed properly. Since EMS providers treat a variety of patients and operate in a variety of environments, providers may be exposed to potentially pathogenic organisms, serving as vectors for the exposure of their patients to these same organisms. Proper application of accepted standards for hand hygiene can help reduce the presence of microbes on provider hands and subsequent transmission to patients and the environment. (1)

Another study aimed to demonstrate potential spread of microbes during actual EMS activities. Bacteriophage was used to trace cross-contamination and evaluate current disinfection practices

and a hydrogen peroxide (H2O2) wipe intervention within emergency response vehicles. Prior to EMS calls, 2 surfaces were seeded with the bacteriophage solution. On call completion, the EMS vehicle and equipment surfaces were sampled before decontamination, after decontamination per current practices, and after implementation of the intervention. Results suggested firefighters' hands were the main vehicles of microbial transfer. Current practices were not consistently applied or standardized and minimally reduced prevalence and quantity of microbial contamination on EMS surfaces. Although use of a consistent protocol of H2O2 wipes significantly reduced percent prevalence and concentration of viruses, the authors' recommendation was for increased training and promotion of surface disinfection. (2)

Bucher , Donovan , Ohman-Strickland , McCoy conducted a hand hygiene survey whose primary and secondary goals were to determine the reported rates of hand washing and stethoscope cleaning in emergency medical services (EMS) workers, respectively. There were 1,494 responses. Overall, reported hand hygiene practices were poor among pre-hospital providers in all clinical situations. Women reported that they washed their hands more frequently than men overall, although the differences were unlikely to be clinically significant. Hygiene after invasive procedures was reported to be poor. The presence of available hand sanitizer in the ambulance did not improve reported hygiene rates but improved reported rates of cleaning the stethoscope. Providers who brought their own sanitizer were more likely to clean their hands. The study concluded that reported hand hygiene is poor amongst pre-hospital providers and echoed a need for future intervention to improve reported performance in pre-hospital provider hand washing. (3)

Luksamijarulkul and Pipitsangian sought to assess microbial air quality and bacterial surface contamination on medical instruments and the surrounding areas among 30 ambulance runs during service. Groups or genus of isolated bacteria and fungi were preliminarily identified by Gram stain and lactophenol cotton blue. Data were analyzed using descriptive statistics, t-test, and Pearson's correlation coefficient with a p-value of less than 0.050 considered significant. (4) This study revealed high microbial contamination (bacterial and fungal) in ambulance air during services and higher bacterial contamination on medical instrument surfaces and allocated areas after ambulance services compared to the start of ambulance runs. Additionally, bacterial and fungal counts in ambulance air showed a significantly positive correlation with the bacterial surface contamination on medical instruments and allocated areas. (4) The authors of this study suggested that more studies should be conducted to determine the optimal intervention to reduce microbial contamination in the ambulance environment.

In Europe, a regional study examined the levels of bacterial contamination in Welsh ambulances over a 12-month period on a monthly schedule. The results showed a variety of microbes were present in the samples before cleaning the emergency vehicles - most important though is the observation of fresh contamination in ambulances of previously uncontaminated zones in the vehicle due to cleaning methods. Unacceptable levels of microbes were found re-emphasizing the need for more stringent infection control programs. (5)

The ambulance service in Saudi Arabia is managed by the Saudi Red Crescent Society Authority (SRCSA). By 2009, there were approximately 1,300 ambulances in the SRCSA, and 447 EMS centers run by 5,507 staff in the country. (6) The SRCSA conducted a study of 10 busy ambulances operating both in the day and night shifts. All ambulances had similar configuration as per the recommendations of Saudi EMS. Micro-organisms isolated from 3 sites of all the ambulances were included in the study. The most common organisms isolated include *Bacillus species (sps)*, coagulase negative *Staphylococci*, and *Enteric* bacteria. The tested fumigation technique was successful in reducing most of the bacterial contamination. A total of 9 ambulances showed no growth of micro-organisms. A similar density of growth and types of microbes was found in samples collected both during the day and night. The prevalence rates of growth observed from the 3 different sampling sites were in the range of 80-100% before fumigation. In post-fumigation, there was approximately a 60-90% decrease in the incidence of microbes. (6) This indicates the significance of disinfection and sterilization techniques in prevention of disease transmission.

Andersen et al. 2006 found three successive exposure cycles with hydrogen peroxide aerosol capable of producing inactivation of atrophaeus spores in ambulance placement sites. Hydrogen peroxide exposure times of 210 minutes achieved complete inactivation of all spore samples in the ambulance. (7) A programmable device providing a dry fume of 5% hydrogen peroxide disinfectant was tested for decontamination of rooms, ambulances and different types of medical equipment. Pre-set concentrations were used per the volumes of the rooms and garages. Three cycles were performed with increasing contact times. Decontamination was effective in 87% of 146 spore tests in closed test rooms and in 100% of 48 tests in a surgical department when using three cycles. One or two cycles had no effect. In the ambulances, the penetration of H2O2 into equipment, devices, glove boxes, under mattresses, and the drivers' cabins was 100% (60/60 tests) when using three cycles, but was less effective when using one or two cycles. In conclusion, a hydrogen peroxide dry fumigation system, run in three cycles, seemed to have a good sporicidal effect when used in rooms, ambulances, and external and internal parts of ventilated equipment. Further studies need to be performed concerning concentration, contact time and the number of cycles of. This is especially important for inner parts of medical equipment that cannot be ventilated during the decontamination process. (7)

A similar study by French (et al. 2004) conducted in a hospital ward reported 100% inactivation of atrophaeus spore indicators and only 98.8% inactivation of MRSA swab samples, indicating that environmental MRSA contamination may be more likely to survive hydrogen peroxide aerosol than commercially prepared spore indicators. (8)

Discussion

Meeting best practices for cleaning and disinfection of environmental surfaces and patient care equipment constitutes an important factor in preventing the spread of infections. Environmental surfaces and patient care equipment can serve as reservoirs for pathogenic microorganisms. Without clear written policies and procedures for the care, cleaning, and disinfection of transport vehicles and equipment, patients and EMS teams are at increased risk. The most common means of infection transmission occurs when gloved or ungloved hands touch a contaminated surface and/or there is patient contact with contaminated surfaces or medical equipment.

In December 1991, the Occupational Safety and Health Administration (OSHA) issued a standard titled "Occupational Exposure to Bloodborne Pathogens." (8) The OSHA BBP rule applies to all persons occupationally exposed to blood and other potentially infectious materials. One of the requirements under the standard is ensuring that each place of employment be kept clean and sanitary. This involves development and implementation of protocols and procedures addressing work practices for employees that include cleaning schedules and appropriate methods of decontamination and disinfection. All equipment and environmental working surfaces must be cleaned and decontaminated with an appropriate disinfectant after contact with blood and other potentially infectious materials.

Transport personnel are frequently unaware of responsibilities and specific cleaning protocols, therefore it is critical that protocols and routines for cleaning surfaces and medical equipment be established and posted. These protocols should list all items to be cleaned and disinfected, frequency for performing the task (e.g., after patient use or daily), product to use for cleaning/disinfecting, how to clean/disinfect the item and person(s) responsible for performing these tasks.

Per the OSHA BBP Standard, compliance monitoring and evaluation of cleaning and disinfection and safe work practices should be conducted on a regular basis by transport team leadership, management or designated persons. All employees and volunteers should receive feedback on monitoring activities and education in disinfection protocols and safe work practices on an annual basis and as needed.

To understand the general principles for cleaning and disinfection, it is important to clarify some key definitions. Cleaning is the first step and involves the physical removal of dust, soil and organic material from a surface before disinfection can take place. The use of friction is necessary to remove visible soil, debris and organic material. Decontamination is the process of removing disease-producing organisms to render an item safe for handling.

Disinfection is defined as using an agent that destroys or inactivates nearly all disease-producing microorganisms, except for bacterial spores, which are primarily killed by sterilization or high-level disinfection.

New disinfectant products, such as pre-moistened disinfectant wipes, make surface cleaning and disinfection an easy, one-step process that is acceptable for high-touched items that are not

visibly soiled, such as stethoscopes, BP cuffs, monitors and stretchers. It is important to note, however, that for items that are visibly soiled with blood or body fluids, one wipe must be used first to clean and remove the visible soil, then use a second wipe to achieve disinfection.

Because choosing the appropriate surface disinfectant can be confusing, it is critical to look at both label claims and technical data sheets for disinfectant efficacy and safety data. Technical data sheets will list microorganisms that include bacteria, viruses and fungi that achieved efficacy testing and the kill times for each microorganism. Product labels will indicate key bacteria, all viruses and fungal organisms tested, active ingredients, directions for use, cautions and precautionary statements. Labels will also indicate overall contact time for the disinfectant. Contact time is the time the disinfectant solution must remain wet on the surface to achieve efficacy against microorganisms.

Recommendations

Disinfection of noncritical patient care equipment and environmental surfaces should be included as part of EMS Standard Operating Procedures (SOP) manuals. When dealing with problem pathogens, the key activities for prevention and management are to focus on following strict cleaning and disinfecting practices, hand hygiene and appropriate use of personal protective equipment. It is time for EMS agencies to evaluate their practices.

We support the recommendations that comprehensive infection control education programs help in understanding disease transmission and etiology of infections. This is important for EMS providers and will help in decreasing the transmission of infection due to better infection control processes by all the staff and cleaning personnel.

It is important to have an evidence-based and cost-effective approach. Such a comprehensive approach will enable the best control of probable nosocomial infections that may arise from pre-hospital infection due to exposure in ambulances. There is a definite need for stricter implementation of more frequent ambulance disinfection programs. Many occupationally acquired infections can be limited by proper awareness program, training initiatives, and stringent guidelines for ambulances.

Here are some up-to-date steps for EMS to minimize disease transmission:

- Consistently use proper personal protective equipment (PPE) to reduce exposure to blood and other potentially infectious microorganisms. The PPE guidelines have recently been updated to manage highly pathogenic infectious diseases such as Ebola.
- When purchasing new ambulances, choose surfaces that contain polymers that are resistant to microorganism attachment.
- Stay up to date on the recommended immunizations for health care workers
- Follow CDC recommendations that all HCP including EMTs and paramedics receive annual vaccination against influenza.

- Establish isolation protocols with health care organizations so that providers can prepare and safely respond to patients with antibiotic resistant organisms.
- Use CDC recommended disinfection supplies and processes that kill even the toughest microorganisms. These guidelines have recently been updated to manage extreme infectious and contagious diseases such as Ebola.
- Establish a protocol for the routine disinfection of medical devices and the ambulance patient care area and follow it closely.

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