CPR – A RISK TO HEALTH CARE PROVIDERS?

By Judy Boehm, RN, MSN, and Judy Ptak, RN, MSN*

When participating in a resuscitation, all thoughts and actions of the health care providers (HCPs) are devoted to saving a life - not on preventing infection in themselves. But you can set up processes of care so that good infection control principles are followed by all. Each of the participants can help remind others to keep the environment safe. The first half of this article speaks to underlying principles of infection control: methods by which infections are transmitted, infectious diseases that are of concern in the hospital setting, and a summary of Standard Precautions along with the three types of Transmission-Based Precautions. In the second half of the article, infection control measures that should be applied to all resuscitations are reviewed, followed by an in-depth discussion of how resuscitation is altered in the presence of Airborne Precautions. The article ends with suggestions on how to promote adherence to infection precautions during resuscitations. This article will not be discussing transmission-based precaution requirements for the environment, textiles and laundry, decontamination of equipment and the room, or food handling.

Transmission of Infection

Infections may be caused by bacteria, viruses, fungi or parasites. All of these may be transmitted in the healthcare setting. Three elements are necessary for an infection to spread from one person to another:

- A source of the pathogen
- A susceptible person
- A way for the pathogen to get from the source to the susceptible person

The source of the pathogen may be persons who have an active infection, who are in the asymptomatic and/or incubation period of an infectious disease, or who may be transiently or chronically colonized with pathogenic microorganisms.[1] The susceptible person could be a patient or the HCP. Transmission of pathogens occurs by three different modes: Contact transmission, Droplet transmission, and Airborne transmission.

Contact transmission is the most common mode of transmission and can be divided into direct and indirect contact transmission. Direct contact transmission occurs when pathogens are transferred directly from the source to another person without an intermediate object or person (e.g. scabies). Indirect contact transmission occurs when pathogens are transferred from the source to another person via an intermediate object or person. The hands of HCPs frequently are the intermediate object that transmits pathogens from the source to a susceptible person, such as another patient.

*Judy Ptak, RN, MSN, has been an Infection Prevention Practitioner at Dartmouth-Hitchcock Medical Center in Lebanon, New Hampshire, for the past seven years. She is a member of the Association for Professionals in Infection Control and Epidemiology. Her masters degree is in Institutional Epidemiology from Wayne State University.

Droplet transmission occurs when large particle respiratory droplets produced by air forcibly expelled from the upper airway (during talking, coughing, sneezing, suctioning, endotracheal intubation, etc.) reach the mucosal surfaces of a susceptible person. Droplets generally do not travel long distances from their source (3 to 6 feet) and do not remain suspended in the air. Droplet precautions do not require that the source be cared for in a room with negative air pressure.

Airborne transmission involves the production of microscopic particles or droplet nuclei that are able to remain viable while suspended in the air. These tiny particles, produced when air is forcibly exhaled from the respiratory system, are able to travel a significant distance from the source and make contact with a susceptible host. A room with negative pressure is required to prevent the infectious particles from traveling on air currents to other areas.

Infectious Diseases that may be Acquired in Healthcare Settings

In Table 1 find the diseases which are of major concern in the healthcare settings. Note the mode of transmission of infection for each disease.

Table 1 Infectious Diseases of Most Concern in the Healthcare Setting

Disease	Prevalence	Risk to Health Care Provider	Mode of Transmission
Avian influenza	Uncommon – has not been documented in North America	Degree of risk unknown	Droplet, possibly Airborne
Chickenpox, disseminated zoster	Local outbreaks have occurred	Highly contagious to non-immune persons	Airborne and Contact with fluid from lesions
Clostridium difficile	Outbreaks occurring	Some risk	Contact with stool
ESBL - Extended spectrum beta-lactam producing bacteria	Not common but numbers increasing	Some risk	Contact
Hepatitis B and C	Always present	Some risk	Contact with blood and body fluids
HIV	Always present	Some risk	Contact with blood and body fluids
Measles	Local outbreaks have occurred	Highly contagious to non-immune persons	Airborne
Meningococcal meningitis	Uncommon	Some risk	Droplet
MRSA – Methicillin-resistant *Staphy-lococcus aureus*	Always present	Some risk	Contact
Pertussis	Always present, outbreaks occur	Some risk	Droplet
Seasonal influenza	Frequent during the winter months (Flu Season)	Significant risk	Droplet
SARS	No documented cases in several years	Degree of risk unknown	Contact, Droplet, possibly Airborne
Tuberculosis	Common in some populations	Some risk	Airborne
VRE – Vancomycin-resistant *enterrococci*	Always present	Some risk	Contact

Standard Precautions

There are two tiers of precautions to prevent transmission of infectious agents, Standard Precautions and Transmission-Based Precautions.[1] Standard Precautions are intended to be applied to the care of all patients in all healthcare settings, regardless of the suspected or confirmed presence of an infectious agent. Transmission-Based Precautions are for patients who are known or suspected to be infected or colonized with infectious agents, who require additional control measures to effectively prevent transmission.

Standard Precautions are based on the principle that all blood, body fluids, secretions, excretions (except sweat), non intact skin, and mucous membranes may contain transmissible infectious agents.[1] Standard Precautions include a group of infection prevention practices that apply to **all** patients, regardless of suspected or confirmed infection status, in any setting in which healthcare is delivered. These precautions include hand hygiene; use of gloves, gown, mask, eye protection, or face shield, depending on the anticipated exposure; and safe injection practices. Also, equipment or items in the patient environment likely to have been contaminated with infectious body fluids must be handled in a manner to prevent transmission of infectious agents.

The application of Standard Precautions during patient care is determined by the nature of the HCP-patient interaction and the extent of anticipated blood, body fluid, or pathogen exposure.[1] Mouth, nose, and eye protection is used to protect the mucous membranes of the eyes, nose and mouth during procedures and patient-care activities that are likely to generate splashes or sprays of blood, body fluids, secretions and excretions. The Centers for Disease Control and Prevention (CDC) further recommend that during aerosol-generating procedures (e.g. bronchoscopy, suctioning of the respiratory tract, positive pressure ventilation via a face mask, endotracheal intubation), in patients who are **not** suspected of being infected with an agent for which respiratory protection is otherwise recommended (e.g. tuberculosis, SARS), a face shield that fully covers the front and sides of the face, a mask with attached shield, or a mask and goggles (in addition to gloves and gown) be worn. During aerosol-generating procedures on patients with suspected or proven infections transmitted by respiratory aerosols (e.g. SARS, tuberculosis), wear a fit-tested N95 or higher respirator in addition to gloves, gown, and face/eye protection.

Table 2, reproduced from the CDC, outlines the components of Standard Precautions.[1]

Table 2 Recommendations for Application of Standard Precautions for the Care of all Patients in all Healthcare Settings

COMPONENT	RECOMMENDATIONS
Hand hygiene	After touching blood, body fluids, secretions, excretions, contaminated items; immediately after removing gloves; between patient contacts.
Personal protective equipment (PPE) Gloves	For touching blood, body fluids, secretions, excretions, contaminated items; for touching mucous membranes and nonintact skin.
Gown	During procedures and patient-care activities when contact of clothing/exposed skin with blood/body fluids, secretions, and excretions is anticipated.
Mask, eye protection (goggles), face shield	During procedures and patient-care activities likely to generate splashes or sprays of blood, body fluids, secretions, especially suctioning, endotracheal intubation.
Soiled patient-care equipment	Handle in a manner that prevents transfer of microorganisms to others and to the environment; wear gloves if visibly contaminated; perform hand hygiene.
Needles and other sharps	Do not recap, bend, break, or hand-manipulate used needles; if recapping is required, use a one-handed scoop technique only; use safety features when available; place used sharps in puncture-resistant container.
Patient resuscitation	Use mouthpiece, resuscitation bag, other ventilation devices to prevent contact with mouth and oral secretions.
Patient placement	Prioritize for a single-patient room if patient is at increased risk of transmission, is likely to contaminate the environment, does not maintain appropriate hygiene, or is at increased risk of acquiring infection or developing adverse outcome following infection.
Respiratory hygiene/cough etiquette	Instruct symptomatic persons to cover mouth/nose when sneezing/coughing; use tissues and dispose in no-touch receptacle; observe hand hygiene after soiling of hands with respiratory secretions; wear surgical mask if tolerated or maintain spatial separation of >3 feet if possible.

Hand hygiene has been cited frequently as the single most important practice to reduce the transmission of infectious agents in healthcare settings. Hand hygiene is recommended by the CDC under the following situations:[1]

- Before having direct contact with patients
- After contact with blood and body fluids
- After contact with a patient's intact skin
- After contact with inanimate objects (including medical equipment) in the patient's environment
- After removing gloves

The term "hand hygiene" includes both hand washing with either plain or antiseptic-containing soap and water, and use of alcohol-based products that do not require use of water. Hand hygiene following glove removal further ensures that the hands will not carry potentially infectious material that might have penetrated through unrecognized tears or that could contaminate the hands during glove removal.

Most of us think that we know how to don and remove Personal Protective Equipment (PPE) correctly. But if the PPE are inappropriately used, they can be a source of contamination and spread of infection. The CDC has a simple page of instructions found below in Tables 3 and 4.[1]

Table 3 How to Safely Don Personal Protective Equipment

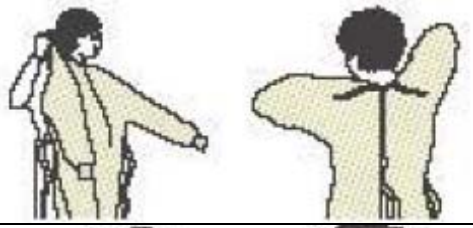
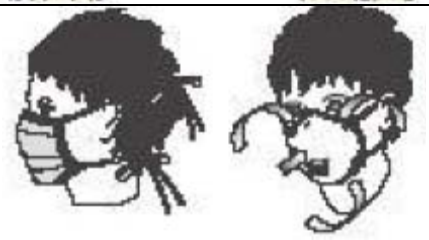
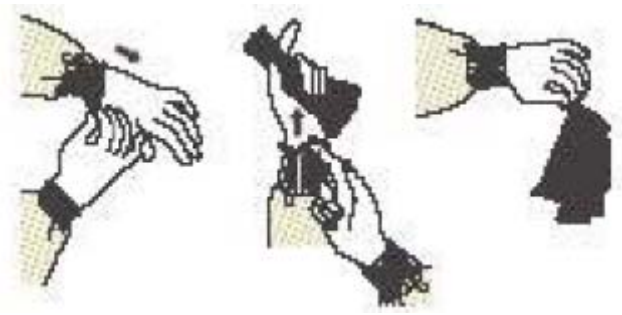
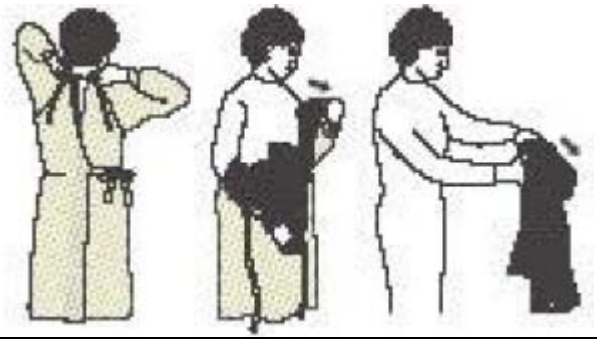
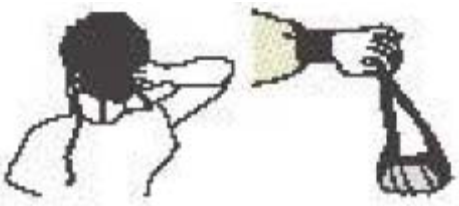
Gown • Fully cover torso from neck to knees, arms to end of wrist, & wrap around the back • Fasten in back at neck & waist	
Mask or Respirator • Secure ties or elastic band at middle of head & neck • Fit flexible band to nose bridge • Fit snug to face & below chin • Fit-check respirator	
Goggles/Face Shield • Put on face & adjust to fit	
Gloves • Use non-sterile for isolation • Select according to hand size • Extend to cover wrist of isolation gown	
Safe Work Practices • Keep hands away from face • Work from clean to dirty • Limit surfaces touched • Change PPE when torn or heavily contaminated • Perform hand hygiene	

Table 4 How to Safely Remove Personal Protective Equipment

Remove PPE at doorway before leaving patient room or in anteroom	
Gloves • Outside of gloves are contaminated! • Grasp outside of glove with opposite gloved hand; peel off • Hold removed glove in gloved hand • Slide fingers of ungloved hand under remaining glove at wrist & remove, turning inside out • Hold removed gloves away from body & discard into waste receptacle	
Goggles/Face Shield • Outside of goggles or face shield is contaminated! • To remove, handle by "clean" head band or ear pieces • Place into designated receptacle for reprocessing or in waste container	
Gown • Gown front & sleeves are contaminated! • Unfasten neck, then waist ties • Remove gown using a peeling motion; pull gown from each shoulder toward the same hand - turn inside out • Hold removed gown away from body, roll into a bundle & discard into waste or linen receptacle	
Mask or Respirator • Front of mask/respirator is contaminated – DO NOT TOUCH! • Grasp ONLY bottom then top ties/ elastics & remove • Discard in waste container	
Hand Hygiene Perform hand hygiene immediately after removing all PPE!	

Transmission-Based Precautions

There are three categories of Transmission-Based Precautions: Contact Precautions, Droplet Precautions, and Airborne Precautions. Transmission-Based Precautions are used for patients with documented or suspected infection or colonization with highly transmissible or epidemiologically-important pathogens when the route(s) of transmission is (are) not completely

interrupted using Standard Precautions alone.[1] For some diseases that have multiple routes of transmission, e.g. SARS, more than one Transmission-Based Precautions category may be used. When used either singly or in combination, Transmission-Based Precautions are always used in addition to Standard Precautions.

Contact Precautions are intended to prevent transmission of infectious agents which are spread by direct or indirect contact with the patient or the patient's environment. Contact Precautions also apply where the presence of excessive wound drainage, fecal incontinence, or other discharges from the body suggest an increased potential for extensive environmental contamination and risk of transmission from any microorganism that is present in these substances.

Find in Table 5 a summary of the safeguards that should be applied for Standard Precautions and the three types of Transmission-Based Precautions.[1] For a patient on Contact Precautions, donning of PPE upon room entry and discarding before exiting the patient room is done to contain pathogens, especially those that have been implicated in transmission through environmental contamination (e.g. VRE, C. *difficile*, MRSA).

Table 5 Precautions for Control of Infections in the Hospital

Type of Precaution	When to Use	Hand Hygiene	Gloves	Facial Protection	Gowns	Type of Room
Standard	All encounters with all patients	Before & after every contact with a patient	For contact with blood & body fluids or items contaminated with blood & body fluids	When splashing or spraying of blood or body fluids is anticipated	When it is likely that blood or body fluids will contaminate clothing or skin	No special room required
Contact	When environmental contamination with pathogen is likely	Before & after every contact with a patient	When entering room	When splashing or spraying of blood or body fluids is anticipated	When contact with the patient or their imme-diate envi-ronment is likely	Private room is preferred
Droplet	When pathogen is spread by respiratory secretions that do not travel long distances	Before & after every contact with a patient	For contact with blood & body fluids or items contaminated with blood & body fluids	When within 3 to 6 feet of the source	When it is likely that blood or body fluids will contaminate clothing or skin	Private room is preferred
Airborne	When pathogen is spread by tiny particles that can remain suspended in the air	Before & after every contact with a patient	For contact with blood & body fluids or items contaminated with blood & body fluids	Special N95 masks or personal air purifying respirators are required	When it is likely that blood or body fluids will contaminate clothing or skin	Room with negative air pressure

Droplet Precautions are intended to prevent transmission of pathogens spread via large droplets of respiratory secretions. Because these pathogens do not remain infectious over long distances in a healthcare facility, special air handling and ventilation are not required to prevent droplet transmission. Infectious agents for which Droplet Precautions are indicated include Avian influenza, seasonal influenza, pertussis, and meningococcal meningitis.

Airborne Precautions prevent transmission of infectious agents that remain infectious when suspended in the air (e.g. chickenpox, measles, tuberculosis, and SARS). The preferred placement for patients who require Airborne Precautions is in an airborne infection isolation room (AIIR). This must be a single-patient room that is equipped with special air handling and ventilation capacity, in which the pressure inside the room is negative relative to the surrounding area (i.e. air containing infectious particles will not flow out of the room). A respiratory protection program that includes education about use of respirators, fit-testing, and user seal checks is required in facilities with AIIRs. HCPs caring for patients on Airborne Precautions wear a mask or respirator, depending on the disease-specific recommendations, that is donned prior to room entry.

Infection Control during Resuscitation

During a resuscitation there is ample opportunity for pathogens to be transmitted to the HCPs or other patients in the vicinity by contact, droplet, and airborne means. HCPs may have contact with pathogens on the patient and transmit these pathogens to others if they don't clean their hands or the equipment that has been used. They may transmit these pathogens to themselves via their hands touching their own mucous membranes or non-intact skin. During intubation and ventilation respiratory droplets are generated that can transmit pathogens to people in the immediate area.

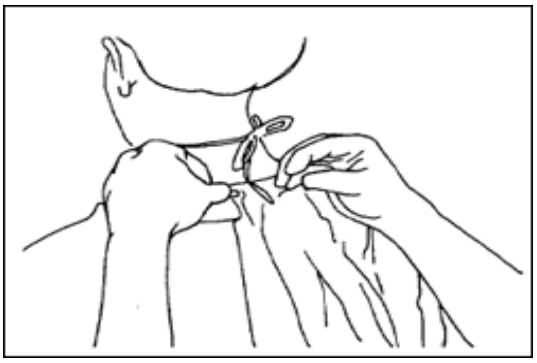
All staff who participate in resuscitations should adhere to Standard Precautions. In this situation when there is a high likelihood of exposure to blood and body fluids, Standard Precautions require gloves, gowns, and eye/face protection. But how often do CPR team members who are participating in direct patient care take the time to don gowns and gloves and eye/face protection? They usually run into the room determined to save a life without thinking of their own safety. Are PPE readily available on the arrest carts to grab? Have ventilation devices (i.e. resuscitation masks and bag/valve/mask devices) with one-way valves been placed strategically on the patient care units and in public areas so that ventilations can be started immediately by HCPs without waiting for the arrival of supplies on the arrest cart or automated external defibrillator? Barrier devices should be handy so mouth-to-mouth ventilation is never even considered.

Supplies used during a resuscitation should move in only one direction – from the clean cart or tackle box to the patient – and never back to the original location. In a recent article Chiang goes even further to suggest that HCPs who work in the "contaminated" zones of the resuscitation room (i.e. the patient, used defibrillators and used intubation equipment) should not cross over to the clean zones, which include the charts and arrest carts."[2] It may be better to have the intubation box remain on a bedside table with the "clean" HCP and the needed items handed to the person performing the intubation since his/her hands will quickly become contaminated with respiratory secretions. Any item placed on the bed should be considered contaminated. At the end of the resuscitation disposable items can be properly disposed of in the room. Any supply

that was not used but was moved into the contaminated zone should be discarded. Reusable equipment should be placed into a plastic bag and the sent for cleaning. Arrest carts should be processed through Central Services.

Have the supplies on the arrest cart been reviewed recently to minimize the risk of a needle stick? Medication syringes are available with only caps – no needles – for administration through stopcocks. During an emergency staff are moving quickly and hands may be shaking so needle sticks can more easily occur. If multiple dose vials were used, they should be discarded at the end of the resuscitation and not saved for use at another code.

When a patient has a disease for which specific precautions are needed, there should be a clear visual alert at the entry to the patient's room. Staff who are providing the general care for the patient should be readily available to inform the CPR team (who often do not know the patient) of the precautions to take and assist them to don appropriate PPE. Isolation carts of PPE should be in place outside the patient room. Staff can help the CPR team don their PPE in these ways:



- Hold the gown so the CPR team member can just slip into it and doesn't have to fumble trying to find the sleeves.
- Tie the back while the CPR member is donning gloves.
- Pull the gloves out of the box and hand them to the CPR team member.
- Have the mask out and ready to go.

Finally, at the end of the resuscitation each person who participated should perform hand hygiene before returning to care of other patients.

Specific Precautions for Resuscitation of a Patient on Airborne Precautions

Resuscitation of a patient on Airborne Precautions in a negative air pressure room has specific challenges. You'll remember that diseases spread via the airborne route are chickenpox, measles, tuberculosis, and SARS. Because aerosol-generating procedures may pose a greater risk of disease transmission, additional precautions are recommended by the CDC for HCPs who perform or assist with these procedures. Aerosols, which require considerable energy to generate, are invisible particles which float on air currents.[3] Healthcare institutions should have a specific resuscitation plan outlined in advance that can be called into action immediately for a patient on Airborne Precautions. It is helpful for the CPR team to know at the outset that their team size and actions will be altered when called to a patient on Airborne Precautions. A hospital may have a different page sent out to the CPR team for such a patient, e.g. "Protected Code Blue", so the team can rehearse the altered action plan in their minds as they are running to the arrest.

The optimal combination of PPE for preventing airborne transmission during aerosol-generating procedures has not been determined. PPE should cover the torso, arms, and hands as well as the eyes, nose and mouth. The following PPE are recommended by the CDC:[4]

- Disposable isolation gown, preferably with fluid-resistant properties. The gown should fully cover the front torso and arms and should tie in the back. A disposable full-body isolation suit is an option and may provide greater protection of the skin, especially around the neck. Surgical hoods, which fully cover the head, neck and face have been used in some settings, but it is unknown whether covering exposed areas of skin or hair on the head will further reduce the risk of transmission.
- Pair of non sterile disposable gloves that fit snuggly over the gown cuff.
- Eye protection (i.e. goggles) that fit snuggly but comfortably around the eyes. (In their SARS document the CDC states that a face shield may be worn over goggles to protect exposed areas of the face but should not be worn as a primary form of eye protection during resuscitation.)
- Respiratory options to protect from inhalation exposure to airborne infectious agents that are microscopic in size:
    - Disposable particulate respirators (e.g. N-95, N-99, or N-100) are the minimal level of protection during a resuscitation. To ensure adequate protection, HCPs must be fit-tested to the respirator model that they will wear and also know how to check the face-piece seal. This check of the seal must be performed prior to entering the patient room. Providers who cannot wear a disposable particulate respirator because of facial hair or other fit limitations should wear a loose-fitting personal air purifying respirator (PAPR).
    - Healthcare facilities in some SARS-affected areas routinely used higher levels of respiratory protection, i.e. PAPR, during resuscitation, but it is unknown whether these higher levels of protection will further reduce transmission.

Unit staff should be positioned outside the patient room to assist CPR team members to don (and remove) the appropriate PPE. Clean supplies to accommodate the PPE should be available outside the patient room.[4] Placing them on an isolation cart ensures that the supplies are standardized and readily available. If PAPRs are being used, a sufficient number should be ready for the CPR team members. Electrical power is needed on the supply cart to keep the PAPR motors charged. Pagers and watches should be left outside the room or carefully covered by the PPE. Peng, writing about lessons learned in infection control and anesthesia during the Toronto SARS outbreak, recommends double gloving for the anesthesiologist performing intubation and all assistants in this procedure.[5]

The number of persons entering the room for a resuscitation should be kept to a minimum so that disease exposure is limited.[4] Teaching institutions have limited their CPR team to six members in the presence of Airborne Precautions:[6]

- Physician leader, who selects the six team members to work inside the room and directs others to remain outside
- Procedure physician – this could be the anesthesiologist who will remain at the code for its duration to perform other procedures
- Registered nurse, who provides supplies off the arrest cart and also documents
- Registered nurse at the bedside, who performs/assists with procedures
- Respiratory care provider
- Person to perform compressions – this should be an upper level resident so s/he can perform other procedures

An institution should develop guidelines for the provision of ventilation of a patient on Airborne Precautions during resuscitation so that the HCPs are maximally protected. Since non-invasive ventilation with a mask can aerosolize respiratory secretions, guidelines might outline that a first responder to a cardiopulmonary arrest only provide oxygen via a non-rebreather mask or nasal prongs.[6] This could already be in place as the method of oxygen therapy. If oxygen is provided via nasal prongs, a surgical mask should be placed over the patient's nose and mouth and nasal prongs. Once oxygenation is assured, the first responder can move on to performing compressions. When a second responder arrives, a bag/valve/mask device can be used with one person holding the mask on the patient to ensure a seal on the face and the other person compressing the bag. The two-person method for ventilation is used to help prevent respiratory secretions from being forced out from under the mask.[5] Once the patient is intubated and the tube secured, ventilations can be provided by one responder. The resuscitation bag should be disposable and have a submicron filter on the exhalation valve, though the effectiveness of this measure in reducing disease transmission is unknown.[4]

High risk respiratory procedures (e.g. intubation and tracheostomy) should be performed by an experienced provider. Resuscitation of a patient with Airborne Precautions should not be considered a learning situation.

Since we are on the subject of respiratory management, the CDC recommends that intubation should be considered sooner rather than later in disease management when a patient is on Airborne Precautions.[4] It is better to monitor patients carefully and plan ahead for intubation in a controlled, careful manner whenever possible rather than waiting until the patient arrests. The patient should be sedated/paralyzed for intubation in order to minimize aerosol generation.

Keep doors to the patient room closed except when entering or leaving the room, and minimize entry and exit during the resuscitation. The arrest cart should be brought into the room, and remain inside for the duration of the resuscitation. Specimens can be handed out the door to an assistant, who completes the requisition and sends/takes it to the lab. If portable x-ray or echocardiography equipment is brought into the room, external surfaces should be wiped with an Environmental Protection Agency-approved hospital disinfectant upon removal from the room.

If the patient is transported to another area of the hospital at the conclusion of the resuscitation, cover the patient with clean linen and a clean gown. Leave as much of the soiled linen in the original room as possible. If the patient is intubated, tape the connection with the bag or ventilator to prevent accidental disconnect during transport. For the patient who is not intubated, place a mask on the patient, either a non rebreather or surgical mask. Consider sedation for the patient during transport to lessen events such as coughing that may contaminate the environment. Prior to transporting the patient, CPR team members should remove PPE that was worn during the code and don clean gown, gloves, and respirator mask and goggles – or a clean PAPR hood and motor unit. Removal of PPE in a manner that prevents contamination of clothing and skin is a priority. Transport the patient through non-public areas whenever possible.

Promoting Adherence with Infection Precautions during Resuscitations

Achieving adherence with infection precautions during resuscitations begins with an institutional culture of safety that permeates care of all patients from the healthy newborn to the critically ill undergoing resuscitation. Training in infection control should be held on a regular basis. In addition to review of protocols during this training, the modes of disease transmission should be highlighted. But even when HCPs have adequate knowledge, they still need to enhance their skills by practicing how to use PPE. Experience from Hong Kong suggests that SARS among 'protected' healthcare workers was related to how well the precautionary measures were used.[5] Educational interventions that incorporate videotaping and performance feedback have been successful in improving adherence.[8]

"Most important of all is the 'hypervigilence'of healthcare workers in practicing infection control measures."[4]

Among nurses and physicians, increasing years of experience is a negative predictor of adherence to infection control precautions.[9] Moore states that "Physicians, perhaps because they operate somewhat outside the established workplace health and safety system, are often the least compliant, despite having arguably the most knowledge."[10] How does the practice of infection control measures during resuscitation become the expected group norm? Can CPR team-based teaching of infection control during resuscitation affect this attitude?

So, how compliant are HCPs with infection control measures during actual resuscitations? Chiang used videotaping in a Taiwan emergency room to evaluate compliance with the use of PPE during resuscitations between November 2005 and April 2006.[2] The overall rates for wearing PPE were reported as:

- 90% for masks
- 50% for eye protection
- 20% for gowns
- 75% for gloves

He reported that the frequency of contamination, i.e. a HCP moving from a contaminated zone to a clean zone, was 687 events during 44 consecutive resuscitations. Among all the clean zones, arrest carts used to stock intravenous lines and medications were the most frequently contaminated sites. Nursing staff were more likely to commit contamination errors than physicians. The two leading system sources of contamination were 1) lack of specific task assignment among rescuers, i.e. a staff member was assigned two or more tasks across the clean and contaminated zones during the resuscitation, and 2) inadequate preparation for procedures, an indication that equipment for a specific task was not prepared and assembled beforehand so that the staff had to move back and forth between the clean and contaminated zones. The following system changes were suggested to reduce contamination:

- More specific task assignment for responders
- Better preparation before performing invasive procedures
- Better spatial and personnel arrangement in the resuscitation room
- Clearer demarcation between clean and contaminated zones

During the SARS outbreak in Toronto simulation training was used with the resuscitation team at St. Michael's Hospital to perfect their infection precautions protocol as well as to train the cardiac arrest team.[11] A full arrest scenario was simulated using a Laerdal SimMan placed in a bed in an empty negative-pressure patient room, including the transport of the resuscitated patient to the intensive care unit. In preparation, all necessary equipment to manage a SARS cardiac arrest was placed outside the room and HCPs who would respond to an actual SARS cardiac arrest were present. Through their training St. Michael's identified problems in their processes of care which lead to changes in their protocols. Lessons learned from their findings include:

- Their modified ACLS protocol for a SARS cardiac arrest was called as a "Code Blue Special" (CBS).

- When 4 members of the arrest team were simultaneously dressing, it took between 3½ and 5½ minutes for the fastest team member to dress, even with assistants aiding verbally and physically. This longer time than anticipated seemed to be due to healthcare workers and assistants talking at the same time to request equipment, and the workers reaching across each other for equipment. They subsequently developed a cart for PPE that was portable and allowed 4 HCPs to access it simultaneously. It also had numbered equipment labels allowing the workers to follow the dress-up procedure visually without memorizing the steps. To expedite dressing they put up wall posters demonstrating the dress-up procedure and used one dressing assistant per 2 team members.
- Once it was realized how long it took to don the PPE, they decided that defibrillation could be performed by any physician on the unit wearing an N95 respirator, goggles, gown and two pairs of gloves. Using multifunction electrodes, hands-off defibrillation could be accomplished by pushing a button on the defibrillator positioned about 2 meters from the patient. They also proposed that all patients with SARS be placed on cardiac telemetry so lethal arrhythmias could be noted earlier and the defibrillator brought into the room by the first responder.

- Since the earpieces of a stethoscope could not be placed in the ears when wearing the PAPR, they used a portable end-tidal CO_2 detector as the initial method to confirm tracheobronchial placement of the endotracheal tube. They didn't use an esophageal detector device because of infection concerns with applying negative pressure to the airway of the SARS patient.

- Ergonomic limitations when wearing the PAPR were observed, e.g. claustrophobia; the need to perform shorter periods of cardiac compressions due to heat fatigue; difficulty communicating with each other due to the noise generated by the high flow through the PAPR.

- No drugs were permitted to be delivered via the endotracheal tube.

- There was no policy for transporting a SARS victim from the ward to the ICU, so one was developed.

- Removal of PPE was more complicated than expected and often resulted in contamination. One example was the difficulty in removing the contaminated outer pair of gloves without contaminating the clean inner pair of gloves. Also, providers were often unable to remove the gown without contaminating the uniform underneath. Practice labs were set up as part of the education program for donning/removing PPE.

Conclusion

Knowing how diseases are transmitted is the first step in understanding Standard Precautions and Transmission-Based Precautions. Hospitals should have processes for infection precautions during resuscitation clearly outlined in their CPR policies/procedures. A specific protocol for resuscitation of the patient on Airborne Precautions should be developed and practiced in training scenarios. For infection control precautions to be applied uniformly there must be an institutional commitment to a culture of safety. Your infection control actions during a resuscitation can minimize the risk of infection to yourself and others.

"It's not about the mask, and it's not about the fit testing. It's about a whole system of safety controls."[12]

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