Pandemic Preparedness
Transmission of Influenza and Other Infectious Diseases
The Role of Breathing Filters in the Clinical Setting
January 18, 2006
Speakers

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- **Klaus Züchner**, PhD, Dept. Anaesthesia Technology, University Hospital Göttingen, Germany
- **Andreas Widmer** MD, MSc, Division of Infectious Diseases, University Hospital Basel, Switzerland
- **Joseph Cervia**, M.D., Professor of Clinical Medicine and Pediatrics, Albert Einstein College of Medicine, Medical Director, Pall Corporation, U.S. (*Moderator*)
Impact of Influenza

- According to CDC, 5-10% of U.S. residents contract influenza each year.
- Of these, on average, 200,000 are hospitalized and 36,000 die each year from influenza complications.
- In contrast to such expected seasonal outbreaks, however, occasional viral reassortment may result in sudden, unexpected changes in the virus that create the possibility of a global pandemic.
Pandemic Influenza

• Three such pandemics occurred in the twentieth century.

• CDC estimates that a pandemic of medium severity could cause as many as 45 million cases, resulting in over 700,000 hospitalizations and 200,000 deaths in the U.S. alone.

• As has been learned from other more limited outbreaks of serious respiratory viral illness such as SARS, a flu pandemic would place great strain on human and technological healthcare resources.
Pandemic Preparedness

• WHO has stated that despite advance warning, the world is currently ill-prepared to defend itself during a global influenza pandemic.

• Global, national, and local health care authorities and providers will need to educate themselves on the risks of pandemic influenza, and lead the way in efforts to assure that adequate resources are focused upon measures that will optimize preparedness for such an occurrence.
Pandemic Influenza and Infection Control

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Division of Healthcare Quality Promotion
National Center for Infectious Diseases
Centers for Disease Control and Prevention
January 18, 2006
Reasons why new pathogens emerge:

– Human exposure to new environments
– Changes in animal or vector exposure
– New procedures (e.g., medical, cosmetic)
– New populations at risk
– New social factors (e.g., crowding, nursing homes)

Established host relationships vs New host relationship
Three Terms for Flu

• Seasonal
  – Annual flu, (H3N2, H1N1, B)
  – Vaccine routinely available

• Avian
  – Numerous strains among birds
  – H5N1 is current strain with incidental disease in humans exposed to ill birds

• Pandemic
  – Reassortment of animal flu (e.g., H5N1) with Human flu strains -> strains able to cause disease in humans with no past immunity
  – H1N1 in 1918, H2N2 in 1957, H3N2 in 1978
Avian Influenza in Asia
(22 August, 2005)

Total Cases 148
Deaths 79
Recognizing Avian Influenza

Virus kills Vietnamese girl

Eight-year-old is fifth victim as fears rise over epidemic

Hanoi, Reuters

An eight-year-old girl has been confirmed as the fifth person to die in Vietnam from an outbreak of bird flu, while nine other children with respiratory ailments are being tested for the virus, doctors said yesterday.

The girl, from the northern province of Ha Tay, died on Saturday. She was taken to hospital in Hanoi on January 15 after first showing symptoms on January 11, the World Health Organisation (WHO) said yesterday.

"WHO confirms this is the fifth case of death from H5N1," said Robert Dietz, a spokesman for the UN agency, referring to the strain of bird flu.

The WHO says there has been no sign the disease is being spread between humans. Its victims are believed to have caught it from infected chickens and eating cooked chicken and eggs is safe, officials say. But experts are worried there might be a mixing of the avian flu with a human flu and a new, contagious deadly disease could sweep out of Asia, a year after Severe Acute Respiratory Syndrome emerged and killed about 800 people around the world.

South Korea, Indonesia and Malaysia have reported cases of bird flu in chickens, while China, Taiwan, Turkey and the Netherlands have also confirmed outbreaks. The European Union has reported 25 cases of bird flu in wild birds, mostly ducks and geese. The disease has also been found in wild birds in 23 countries, according to the World Organisation for Animal Health (OIE).

"We hope we can exchange with the CDC experts about the efficacy of treatment," Nguyen Thanh Lien, director of the children's hospital, told Reuters Television in an interview.

The children are being treated with antiviral drugs and antibiotics, he said.

Dr Lien said it was a "mystery" why the human flu cases were clustered in the north, while the chickens were sick in the south. Possible explanations are differing climate conditions and that some cases in the south may not yet have been diagnosed.

Two hospitals in the south have been treating suspected avian flu patients, Kien Giang General Hospital said on Wednesday. A man with symptoms similar to those seen in bird flu victims had died. A woman with the same symptoms was recovering.

Can Tho Paediatric Hospital said yesterday a two-month-old child died on Thursday from respiratory illness.

Can Tho is among the 15 provinces that have declared an outbreak of bird flu. Kien Giang, one of the southernmost provinces in Vietnam, has not reported an outbreak.

Doctors say bird flu in humans looks similar to common flu, with high fever, sore throat and a dry cough that can deteriorate into severe respiratory prob-
Clinical Features of Avian Influenza

• Persistent fever, lymphopenia
• Severe pneumonia or ARDS
  – unusual presentations possible
• Exposure to sick poultry
• Exposure to affected areas or persons
  – Clustering may be an emergency
Containing Pandemic Influenza With Antiviral Agents

- Theoretical models using Thailand data
- Contacts of suspected cases take antiviral agents
- Pandemic contained if $R_0$ low
- Prophylaxis with quarantine more effective
- Critical is speed of detecting cases and response

Longini IM et al. Science 2005
Ferguson et al. Nature 2005
Pandemic Influenza
Goals of Infection Control

• Define and identify cases
• Stop spread of disease
  – In a facility
  – In a population
  – In a geographic region
• Ensure safety for personnel providing care
• Confirm effectiveness of practices
• Prevent inappropriate responses
How do infections spread?
Disease Transmission

*Windows of opportunity*

- Leave original host
- Survive in transit
- Be delivered to a susceptible host
- Reach a susceptible part of the host
- Escape host defenses
- Multiply and cause tissue damage
Infection Control Recommendations for Pandemic Influenza

- Standard Precautions – All the time
- Droplet Precautions – All the time
- Airborne Precautions – for aerosol-generating procedures
Standard Precautions

- Use of gloves and handwashing (plus face-shields, masks or gowns if splashes are anticipated) for any contact with blood, moist body substances (except sweat), mucous membranes or non-intact skin.

- Gloves are removed and discarded immediately after completion of a task.

- Hands are washed every time gloves are removed.

http://www.cdc.gov/ncidod/dhqp/gl_isolation_standard.html
Droplet Precautions

For infections spread by large droplets generated by coughs, sneezes, etc. (e.g., Neisseria meningitidis, pertussis, influenza).

- Face shield or goggles, and a surgical mask (not N-95) are worn to prevent droplets reaching the mucous membranes of the eyes, nose and mouth when within 1 meter of the patient.
- Patients should be separated by 1-2 meters, or be grouped with other patients with the same infection/colonization status.
- Patient should wear a surgical mask when outside of the patient room.
- Negative pressure room is not needed.
Special precautions for high-risk procedures

Patient care:
- Suctioning
- Intubation

Laboratory:
- Centrifugation
- Pipetting
Airborne Precautions

For aerosol-generating procedures (i.e., infections spread by particles <5µ that remain infectious while suspended in the air such as TB, measles, varicella, and variola).

- Negative pressure room.
- Surgical mask on patient.
- N-95 mask for personnel inside negative pressure room.
- Isolation room air should not be recirculated in the building.
- Exhaust air away from people, e.g., off the roof.
Further information is available at

http://www.cdc.gov/ncidod/dhqp/guidelines.html
http://www.hhs.gov/pandemicflu/plan/
Objectives

- Discuss the dilemmas that arose during SARS---many of which are still unresolved
- Explore lessons learned
- Explore some of the ethical issues and current planning in the Province of Ontario re Pandemics/ICU
- New “threats”--- are we prepared?
Disaster Management

• Outbreaks may arise quickly and without much warning taxing the resources and coping abilities of its personnel

• You need to have a plan in advance
The Pandemic Predictions

- ‘Flu Surge’ model: a 35% attack rate over 6 weeks
- Hospital admissions in Ontario for patient with influenza will peak at 1823 per day
- 72% of the total hospital capacity
- Demand for ICU will peak at 171% of current existing bed capacity and 118% of the current ventilator capacity solely for patients with influenza.
- Only takes into account physical system capacity and not the human capacity of the system

http://www.health.gov.on.ca/english/providers/program/emu/pan_flu/flusurge.html
Need to Develop a Plan
Leadership and Organizational issues

- Leaders with key responsibilities are key
- Coordinate efforts
- Develop containment policies
- Coordinate manpower and resource allocation
- Infection control

- Share data and research efforts
- Maintain staff morale
- Coordinate with other institutions
- Coordinate with Government
Manpower and Beds

Need to meet surge in demand and still care for “regular” patients

In SARS:

- Entire hospitals/ICUs were quarantined for 12-14 days
- 38% of tertiary ICU beds and 33% of community ICU beds were closed at some point
- Most ICUs normally operate in this Province at 90-95% capacity
- Staff was reduced from illness, quarantine, fear
Effective Triage System

1. Availability of accurate and up-to-date information about the natural history of the infectious agent, demands on the system, and resource availability.

2. A centralized triage advisory committee with command and control over resources.

3. An efficient communications network that allows two-way communications between the “field” and the command centre.

4. Trained triage officers in the field with the authority to make and enforce triage decisions.

Christian M, Pandemic A/D/T Committee Report 2005
The Challenges

- Lack of Knowledge
- Lack of ability to predict
- Lack of treatment
- Changing nature of disease
- Secondary complications

- Communication/Sharing of information
- Collection of Data
- Sheer volume of patients
- Manpower issues
- Even “common” resources now scarce
Primary Goal of Triage in a Pandemic

“Do the most, for the most”

• Profound shift from current models
  – Need
  – First come, first serve
  – Priority Programs
  – Status

• Triage decisions depend on the patient’s probability of survival AND on the availability of resources.

• Triage of critical care resources will apply to patients with influenza AND to all who require ICU care
Accountability for Reasonableness

• First described by Dr. N. Daniels in 1998
• The strongest emerging ethical model for resource allocation:
• Reasons for decisions be those that “fair-minded people can agree to in face of resource constraints”
  – Relevant
  – Public
  – Enforced
  – Appeals Process

Daniels N., J Urban Health Jun 1999.
How can A4R possibly be applied?

- Relevant
  - Scientific basis
  - Dynamic/adaptation to situation/knowledge

- Public
  - Developed before crisis
  - Made public and rationale discussed

- Enforced
  - Triage officers?

- Appeals Process
  - Command Central Triage Committees? Courts?
  - Likely only a post-Pandemic event
Learning from Others

- Military has used triage systems for many years in mass trauma situations
- The sheer volume of people they are designed to sort make them useful in a pandemic
- In Canada and the U.S. 4 category system of “immediate, delayed, minimal, or expectant” with corresponding number or colour code systems
- Minimum qualifications for survival [MQS] to guide triage decisions

http://www.sfar.org/s/article.php3id_article=60
If we apply this to the ICU.....

Ontario Pandemic A/D/T Committee Working Group 2006

<table>
<thead>
<tr>
<th>Code</th>
<th>Criteria</th>
<th>ICU Priority</th>
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<tbody>
<tr>
<td>Red</td>
<td></td>
<td>HIGHEST</td>
</tr>
<tr>
<td>Yellow</td>
<td></td>
<td>Moderate</td>
</tr>
<tr>
<td>Blue</td>
<td></td>
<td>Palliate</td>
</tr>
<tr>
<td>Green</td>
<td></td>
<td>Reassess</td>
</tr>
</tbody>
</table>

Need to revise as new info becomes available
Need to have ways to clearly and quickly communicate and receive information on:

- Updated diagnostic criteria
- Suspected and established epidemiologic links
- Number of patients/quarantined/at risk
- Prognosis and Rx
- Means of Infection Control
- Infection control issues specific to different settings
- Deal with uncertainty
Lessons from SARS

• Must anticipate equipment needs
• Have some basic stock and a list of suppliers who can ensure rapid increases in demands are met
• Education, Clear Protocols and Training
Surveillance

- Disasters from Infectious diseases will not have clear beginnings or finite ends
- Develop practical ongoing screening and surveillance
- Collaboration across wide geographic regions
- Balance isolation/quarantine and maintenance of freedoms
- Be prepared to be wrong and admit likely will be errors upfront
Communication

• Information needs to be conveyed locally, nationally and internationally

• Lessons from SARS outbreak taught value of
  – websites,
  – Teleconferences
  – Media

• Front-line workers

• Patients and their families

• General Public and Media:
  – need a plan to decrease sensationalism and elicit help
  – Assign one team of professionals
Education

*Need to teach:*

- How to Rx infected individuals
- Mount surveillance
- Observe infection control measures
- Respond to emergency situations

- Collect data and research
- Creation of educational materials/internet based programs
- Creation of mobile education teams
Team Morale/Manpower

- Regular Support meetings
- Debriefings
- Emergency crisis response teams
- Psychiatry
- Commendations and Thank Yous
- Refreshments

- Isolation, fear and anxiety common
- Significant numbers suffered from PTSD and Depressive symptomatology
- Regular communication via teleconferences and emails became new way of support
From Silos to Systems Thinking

• Sharing information, resources and learning from collective experience
• Unprecedented collaboration and communication between all levels of Government, healthcare organizations and front-line workers

Such thinking would lead to:
• Designating specific hospitals as main centres for screening and Rx
• Meet general and more specific needs of other patients
• Devise ways to increase resources
Lobbying

- Make sure others understand your needs
- Get the commitment for help in meeting them from all levels
Conclusions

• The SARS outbreak has lead us to examine who we are --- as individuals and as professionals
• Will we be ready for the next disaster?
• How can we prepare?
• Can we be do better?
• Only by exploring and understanding what went right and what went wrong, only by knowing who we are and want to be, only by learning from our past
Transmission of Influenza and other Infectious Diseases

The Role of Breathing System Filters in the Clinical Setting

Klaus Züchner
University of Göttingen
Aim:

• Prevention of patient to patient transmission
• Prevention of patient to personnel transmission
Clinical Setting:

**Intubated patient:**

- Anaesthesia, OR
- Ventilated patient, ICU
Anaesthesia setting, re-breathing system

\[ \text{CO}_2 + \text{Ca(OH)}_2 = \text{H}_2\text{O} + \text{CaCO}_3 \]
ICU setting
Heat and Moisture Exchanger, HME
ICU setting
Heated Humidifier, HH
Filtration:

Removal of particles from

- Gas
- Liquid
Assumption:

Micro organisms such as:

- Virus
- Bacteria
- Fungi
- can be treated like particles!
Glass fibre filter
Electrostatic filter I
Electrostatic filter II
Mechanisms of filtration of gas-borne particles

- Interception
- Inertial impaction
- Gravitational settling
- Diffusion
- Electrostatical attraction
Mechanisms of filtration of gas-borne particles
Filtration efficiency [%]

Combined efficiency

Diffusion

Interception/Impaction

Settling

[µm]
The combined efficiencies vary with the size of the particle:

- Particles in the range of 0.05 to 0.5 µm pass the filter more easily
Generally accepted test method for gas-borne particles:

- ISO 23 328-1:2003

**Anthony R. Wilkes**  
MHRA evaluation 04005, March 2004  
Breathing System Filters  
An assessment of 104 breathing system filters

**Result:**  
Glass fiber filters perform best but have only limited moisturizing properties!
Test method for liquid retention properties:

Wilkes, AR

Result
Glass fiber filters perform best!

A generally accepted test method is still missing!
Retention of liquid-borne particles:

The filter must withstand a water column pressure of at least the pop off pressure in the circle system or breathing circuit.
Means of Protection

Anaesthesia:

Filter

CO₂ Absorber
Means of Protection

Anaesthesia:

- Glass fiber filter at the Y-piece position
Means of Protection
ICU ventilation:
Means of Protection

ICU ventilation:
Means of Protection

ICU ventilation:

• HME with filter in the same housing
  Check for good moisturizing properties
• HME with good moisturizing properties
  Separate filter at the ventilator expiratory port
• Heated humidifier with separate filters at the
  ventilator expiratory and inspiratory port
Use of Filters on Anesthesia Breathing Circuit

Andreas F. Widmer, MD,MS
Professor of Medicine & Infectious Diseases
Head, Infection Control
University of Basel Hospitals
Ventilator breathing circuits with HMEs

1) No recommendation can be made for the preferential use of either HMEs or heated humidifiers to prevent pneumonia in patients receiving mechanically assisted ventilation (Unresolved issue) (IB) (44--49).

Guidelines for Preventing Health-Care--Associated Pneumonia, 2003
Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee

There are insufficient clinical outcome data to support the routine use of bacterial filters for breathing circuits or anesthesia ventilators at this time. A filter should be used on the anesthesia breathing circuit between the patient's airway and the Y-connector prior to contacting a patient with or at high risk for having pulmonary tuberculosis.4
Efficacy of heat and moisture exchangers in preventing ventilator-associated pneumonia: meta-analysis of randomized controlled trials

Fig. 1 a
Analysis of Ventilator-associated pneumonia (VAP) in all RCTs comparing heated-water humidifiers with heat moist exchangers

Fig. 1 b
Analysis of VAP in RCTs comparing heated-water humidifiers with heat moist exchangers over 7 days or more of mechanical ventilation

Incidence of blood contamination of tubus after anesthesia

Kristensen et al., 1990
Kanefield et al., 1990
Parker & Day, 2000

% Blut-Kontamination d. ET-Tuben

Kanefield et al., 1990

0 10 20 30 40 50 60 70 80 90 100

76 86 76-78
<table>
<thead>
<tr>
<th>Testmedium/microorganism</th>
<th>Electrostatic Filter</th>
<th>Hydrophobic Filter</th>
</tr>
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<tbody>
<tr>
<td><em>B. diminuta</em>¹,²</td>
<td>4/4¹ and 5/5² failed</td>
<td>1/1¹,² passed</td>
</tr>
<tr>
<td><em>S. aureus</em>³</td>
<td>3/3 failed</td>
<td>1/1 passed</td>
</tr>
<tr>
<td><em>P. aeruginosa</em>³</td>
<td>3/3 failed</td>
<td>1/1 passed</td>
</tr>
<tr>
<td><em>S. marcescens</em>³</td>
<td>3/3 failed</td>
<td>1/1 passed</td>
</tr>
<tr>
<td><em>M. luteus</em>⁴</td>
<td>4/4 failed</td>
<td>1/1 passed</td>
</tr>
<tr>
<td>Water⁵</td>
<td>8/9 failed</td>
<td>3/3 passed</td>
</tr>
<tr>
<td>Water⁶</td>
<td>15/24 failed</td>
<td>5/5 passed</td>
</tr>
<tr>
<td>Hepatitis C Virus⁷</td>
<td>1/1 failed</td>
<td>1/1 passed</td>
</tr>
<tr>
<td>HIV⁸</td>
<td>1/1 failed</td>
<td>1/1 passed</td>
</tr>
<tr>
<td>Prion-Protein⁹</td>
<td>-</td>
<td>1/1 passed</td>
</tr>
</tbody>
</table>

1. Hedley & Alt-Graham, 1992; Anaesthesia 47: 414-420
2. Lee et al., 1992; Brit J Anaesthesia 69: 522 - 525
3. Rosales & Dominguez, 1997; 2nd Int Conf on Prev Inf May
5. Frankenberger et al., 1995; Anaesthesist 44: 581 - 584
6. Wilkes, 2002; Anaesthesia 57: 33 - 39
7. Lloyd et al., 1997; Anaes Int Care 25: 235-238
8. Lloyd et al., 1997; CAMR
9. Capewell, 2004; Pall Technischer Report
Prospective study on Contamination of Ventilator breathing circuits during Anesthesia

- Setting: University Hospital 850 beds, 26,000 surgical interventions/year
- Goal: determine rate of contaminated filters after anesthesia
  Reduce cycles for disinfection of ventilators from once/monthly (recommendation of manufacturer supported by European equivalent to FDA) to 1/year
- Methods:
  Filter transported with sterile lids in sterile container to the microbiology laboratory <4 h after anesthesia
  Filters served as own control
  - outlet patient: study site
  - outlet ventilator: control
**Methods**

CONTROL

- 20ml PBS
- Centrifuge 5000 rpm
- Plating *centrifuge effluent*

Study site

Patient

- 20ml PBS
- Centrifuge 5000 rpm
- Plating *centrifuge effluent*
Patients & Methods

• 224 Filters were studied
• 448 samples
• All filters labelled before transportation to the lab
• No information collected on
  – Type of surgery
  – Duration of surgery
  – Incidence of nosocomial pneumonia
• Cultures for bacteria only:
  No virological studies (HIV, Hep B, C, CMV)
Results

• Controls (ventilator outlet)
  – Positive 12% < 10 CFU/20ml
  – Coagulase-negative staphylococci
  – Corynmbacterium spp

• Study site (patient outlet)
  – Positive culture 12.8%
  – Of those:
    – 25% mixed flora from mouth/pharynx >500 CFU
    – 3% Klebsiella pneumoniae
    – 72% coagulase-negative staphylococci, bacillus spp
      corynebacterium spp
CONCLUSIONS

- Retrograde contamination with clinically significant pathogens occurs in <5% of circuit filters
- None of the control filters demonstrated growth with clinically significant pathogens

- Use of Filters on anesthesia breathing circuit might be useful not only for TB patients, but for other patients at higher risk to contaminate anesthesia breathing circuit
  - Patients with active pneumonia
  - Patients with cystic fibrosis or other chronic pulmonary disease
  - Patients suspected or confirmed (avian) influenza
Key Learning Points

• Reassortment of animal and human influenza strains may produce virus to which humans have no past immunity, resulting in pandemics.

• Outbreaks may arise quickly and without much warning, taxing material and human resources.

• Advance planning is critical to success in addressing such outbreaks, and should include coordinated efforts to develop containment policies, and to anticipate manpower and resource allocation.
• Breathing circuits of intubated patients in ICUs and under anesthesia may be protected by filtration, reducing the risk of viral transmission from an infected patient to other patients and to health care personnel.
Questions?
Thank You