PERSONAL PROTECTIVE EQUIPMENT
IN THE TIMES OF COVID

Neuro-anesthesia Quiz # 63

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Question 1: ASTM requirements for surgical masks

Question 2: Efficiency of N95 respirator

Question 3: Disinfecting N95 respirator

Question 4: Ingredients of hand sanitizer

Question 5: Alternatives to N95 respirator
As per American Society of Testing and Materials (ASTM), the performance requirement for a surgical mask entails all EXCEPT:

A: Bacterial filtering efficiency of ≥ 98%
B: Particle filtering efficiency of 90%
C: Fluid resistance at 160 mmHg
D: An air flow resistance of <5 mmH₂O/cm²
A. Bacterial filtering efficiency of ≥ 98%

BFE (bacterial filtration efficiency) measures how well the mask filters out bacteria when challenged with a bacteria-containing aerosol.

This is tested using a droplet size of 3.0 microns containing Staphylococcus aureus (average size 0.6-0.8-microns).

A level 1 mask should filter out 95% while a level 3 masks should filter out 98% of the bacteria.
B. Particle filtering efficiency of 90%

PFE (particulate filtration efficiency) measures the ability of the mask to filter out sub-micron particles including viruses. This is tested using particle of 0.1-micron size.

A level 1 and 3 masks are required to filter out 95% and 98% of the particles, respectively.

Surgical masks are made of non-woven polypropylene fabric.

Level 3 surgical masks are made of 4 layers of fabric.
C. Fluid resistance at 160 mmHg

Fluid Resistance reflects the mask's ability to protect the wearer from a splash or spray of fluid.

It is tested using synthetic blood at pressures of 80, 120, or 160 mm Hg to simulate the venous, the arterial and the pressure that may be encountered during high pressure irrigation.
D. An air flow resistance of $< 5 \text{ mmH}_2\text{O/cm}^2$

Delta P (pressure differential) measures the air flow resistance of the mask and is an objective measure of breathability.

A controlled flow of air is driven through a mask and the difference in pressure on either side of the mask divided by the surface area of the mask should be $< 5 \text{ mmH}_2\text{O/cm}^2$. 

**EXPLANATION**
Which of the following statements about N95 respirator mask is TRUE?

A: Filters 99% of the 0.3-micron airborne particles

B: It has an Assigned Protection Factor of 95

C: Viruses are about 0.1µm and can easily pass through these masks

D: These masks are NOT resistant to oil aerosol
A. Filters 99% of the 0.3-micron airborne particles

N95 respirators filter 95% of the 0.3-micron airborne particles

[Most Penetrating Particle]

- Particles about 0.3µm size are the hardest to filter, as they are not large enough to be ‘intercepted’ by the fibers, and not small enough to have Brownian motion

Reference slide Q2
B: It has an Assigned Protection Factor of 95

Assigned Protection Factor (APF) means the workplace level of respiratory protection that a respirator or class of respirators is expected to provide to employees.

N95 has an APF of 10, which means that it reduces the aerosol concentration to 1/10 of that in the ambient air, or it blocks 90% of airborne particles from being inhaled.

C: Viruses are about 0.1µm and can easily pass through these masks

COVID-19 virus is about 0.12µm (125nanometer)

However, such small particles move around in random zigzag patterns, known as ‘Brownian motion’, and deviate from the air stream and get caught by the fiber

Particles of around 0.3µm size are the hardest to capture, as they are not large enough to be ‘intercepted’ by the fibers, and not small enough to have Brownian motion

Reference slide Q2
Great Job!! Correct.

EXPLANATION

D: These masks are NOT resistant to oil aerosol

Respirators are rated

• “N” if they are NOT resistant to oil
• “R” if somewhat resistant to oil
• “P” if strongly resistant (oil proof)
Which of the following techniques CANNOT be used to disinfect a N95 respirator before reuse:

<table>
<thead>
<tr>
<th>Option</th>
<th>Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Vaporous Hydrogen peroxide (VHP)</td>
</tr>
<tr>
<td>B</td>
<td>Autoclaving</td>
</tr>
<tr>
<td>C</td>
<td>Ultraviolet germicidal irradiation (UVGI)</td>
</tr>
<tr>
<td>D</td>
<td>Microwave generated steam</td>
</tr>
</tbody>
</table>

Please click on any of the following links to proceed to that question/topic.
A. Vaporous Hydrogen peroxide (VHP)

The VHP cycle included a 10 min conditioning phase, 20 min gassing phase at 2 g/min, 150 min dwell phase at 0.5 g/min, and 300 min of aeration

The filtration and the fit performance was unaffected for up to 20 VHP treatments cycles

B. Autoclaving

Decontamination using an autoclave caused substantial filter degradation to N95 and the particle penetration levels did not meet the levels that NIOSH would allow for approval

C. Ultraviolet germicidal irradiation (UVGI)

Ultraviolet at 0.5–950 J/cm²

The filtration and the fit performance was maintained in 95–100% after 3 cycles

D. Microwave generated steam

Microwave generated steam has been found to be effective 1100–1250 W microwave models (range: 40 sec to 2 min)

The filtration and the fit performance was maintained in 95–100% after 3 cycles

Which of the following statements about the ingredients in Purell®, the commonly used hand sanitizer is FALSE?

A: Isopropyl alcohol is the primary active ingredient
B: Tocopheryl acetate acts as a moisturizer
C: Propylene glycol is added as a moisturizer
D: Isopropyl myristate is an emollient to prevent it feeling oily
Great Job!! Correct.

A. Isopropyl alcohol is the primary active ingredient

Isopropyl alcohol is an anti-bacterial and viricidal, but the primary component of Purell® is ethyl alcohol (70% v/v)
B. Tocopheryl acetate acts as a moisturizer

α-Tocopheryl acetate, also known as vitamin E acetate, is a synthetic form of vitamin E and acts as an antioxidant and moisturizer.

Note: Vit E acetate is used as a thickening agent by illicit THC vape cartridge manufacturers.
C. Propylene glycol is added as a moisturizer

Propylene glycol is a synthetic liquid substance that absorbs water and acts as a moisturizer like glycerin.
D. Isopropyl myristate is an emollient to prevent it feeling oily

Isopropyl myristate is an emollient and used to enhance absorption into the skin. It thickens the consistency and prevents the solution feeling oily.
Which of the following statements about respirators are TRUE?

A: N95 is an international accepted standard nomenclature
B: The elastomeric respirator mask does NOT require a fit test
C: PAPR can have an Assigned Protection Factor (APF) of 1000
D: All N95 respirators are MRI safe

Reference slide Q5  Content Outline  Q 1. 2. 3. 4
A. N95 is an international accepted standard nomenclature
N95 respirators are called by different names globally.
• European Union - FFP2
• China - KN95
• Australia - P2

N95 FFR come in two shapes: the cone and the duckbill.
B. The elastomeric respirator mask does NOT require a fit test

The elastomeric respirator has a face-piece that is made of viscoelastic material such as rubber or medical grade silicon and a replaceable filter cartridge housed in a hard casing. The face piece has to fit tightly on the face and thus requires a fit testing. These are designed to be disinfected and reused. Available as half face-piece which covers the nose and mouth and the full face-piece that also covers the eyes.

Courtesy: Dr. S Rajan
C. PAPR can have an Assigned Protection Factor (APF) of 1000

Powered Air Purifying Respirator (PAPR) blow filtered air into a helmet with a disposable face-piece.

The blower may be fitted with a mechanical filter for particulate matter or even a chemical filter to block out toxic fumes.

Depending on the filter and the face-piece, it may have an APF of 25 to 1000.
D. All N95 respirators are MRI safe

The magnetic field creates a torque to the ferro-magnetic staples that hold the straps and can lift the mask off the face of the user.

The ‘duckbill’ shaped respirator provides the best seal in an MRI suite.

O.M. Murray et al. / Clinical Radiology 75 (2020) 405-407; https://doi.org/10.1016/j.crad.2020.03.029

The battery powered PAPR cannot be used within the magnetic gauss line of the MRI, but the elastomeric mask may be safe as it is made of medical grade silicon or natural rubber, the filter is housed in a polypropylene casing, and the straps are made of nylon.
## Comparing masks (Q1)

<table>
<thead>
<tr>
<th>ASTM criteria for performance</th>
<th>Cloth facemask</th>
<th>Surgical facemask</th>
<th>N95 Respirator</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BFE (3-µm)</strong></td>
<td>x</td>
<td>≥95</td>
<td>≥98</td>
</tr>
<tr>
<td><strong>PFE (0.3-µm)</strong></td>
<td>X</td>
<td>≥95</td>
<td>≥95</td>
</tr>
<tr>
<td>Fluid resistance</td>
<td>X</td>
<td>80 mmHg</td>
<td>160 mmHg</td>
</tr>
<tr>
<td>Delta P- mmH$_2$O/cm$^2$</td>
<td>X</td>
<td>&lt; 4</td>
<td>&lt; 5</td>
</tr>
<tr>
<td>Flammability</td>
<td>X</td>
<td>Class I</td>
<td>Class I</td>
</tr>
<tr>
<td>Comments</td>
<td></td>
<td>Prevents spread of exhaled droplets of the wearer</td>
<td>Protects the wearer</td>
</tr>
</tbody>
</table>

Title slide; Content outline
Masks are made of non-woven polypropylene fabric and do NOT function as a sieve. They trap particles by 4 mechanisms:
- Larger particles are trapped by the physical barrier \([A, B]\)
- Smaller particles move around in random zigzag patterns, known as ‘Brownian motion’, and deviate from the air stream and get stuck to the fiber\([C]\)
- Particles that are charged get attracted to the charged fibers of the filters \([D]\)

Particles about 0.3µm size are the hardest to filter [Most Penetrating Particle]
Hence masks are graded per their ability to filter 0.3µm particles. E.g. HEPA filter - ≥ 99.97% for PM ≥ 0.3 µm
In times of COVID... CDC recommends following methods for disinfection

- Vaporous hydrogen peroxide (VHP) 20 times
- Ultraviolet (UV) radiation - 0.5–950 J/cm² 3 times
- Microwave generated steam 3 times

This was based on

- Degradation of the filtering property
- Structural changes to ‘face-fit’
- No residual chemical hazard for the wearer

Methods such as high temperature steam sterilization, 70% propyl alcohol, soap and water and bleach washing have been shown to degrade the masks

- N95 can be reused if stored in a brown paper bag for 5 days

Ingredients of Purell® (Q4)

- **Ethyl alcohol (70%v/v)** - Primary germ-killing agent
- **Isopropyl alcohol** - Anti-bacterial and viricidal
- **Carbomer** - Creates the non-foaming gel
- **Tocopheryl acetate** - Form of Vitamin E that acts as an antioxidant and moisturizer
- **Glycerin** - Skin moisturizer that absorbs moisture from air and helps spread the solution
- **Propylene glycol** - Moisturizer like glycerin
- **Isopropyl myristate** - Emollient to thicken and prevent it feeling oily
Respirators (Q5)

- Respirators were developed in the early 1900s, to protect miners from hazardous dusts and gases, soldiers from chemical warfare agents, and firefighters from smoke and carbon monoxide. It was introduced into healthcare in 1990s as protection from drug-resistant tuberculosis.

- The Assigned Protection Factor (APF) for Elastomeric respirators
  - Half face-piece – 10; Full face-piece – 50

- PAPR is not recommended in the operating room as the wearer’s unfiltered exhaled breath could contaminate the sterile field.

BACK TO Q5