Evaluation of automated UVC disinfection systems in acute care hospitals

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Background

• Terminal cleaning and disinfection at patient discharge is currently performed manually
  • Time consuming
  • Laborious
  • User-dependent

• Need to identify new technologies that could be:
  • More effective
  • Less costly
  • Less user-dependent
  • Faster
Objectives

1. To evaluate the efficacy of UVC disinfection systems to eliminate pathogens from environmental surfaces

2. To compare the UVC systems with other available technologies
Methods

• Type of study

  • Prospective observational controlled studies

  • 2 complementary types of artificial contamination of surfaces

    1) *In situ* contamination of high-touch surfaces

    2) Stainless steel cubes contamination
Methods

- **In Situ contamination**
  - Direct contamination of surfaces in an empty patient room (ER, ICU & 8NW)
  - S. aureus ATCC 25924
    - 100 microliters of 1/10000 dilution of a stock solution of Staph aureus is used to artificially contaminate high touch (HT) areas
    - Contamination leaves no visual trace
      - Essential to assess effectiveness of manual cleaning
    - Contamination of a control adjacent to the test area
  - Following contamination, disinfection of the room with various methods
    - Manual cleaning by EVS employee, Electrostatic pulveriser, vaporized H2O2 and UVC light
  - Bacterial growth assessed by contact plates (Rodac)
    - TSA with lecithin and tween 80
    - The agar plate is pressed against the previously contaminated high touch area
    - Incubation 18-20 hours at 37°C
High touch areas

N.B. Inoculated HT may differ from one room to another
Room 8825 Regular Cleaning

Room 8818 Hydrogen peroxide device
Room 8824 Electrostatic sprayer
UV system
8 lamps

ROOM 817
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Window ledge

Chair

Washroom door

Night Table

Bed rail

Side table
Results

• **Part 1: In situ contamination**
  • To compare UV light with other known modalities (Normal cleaning, Electrostatic sprayer, Hydrogen peroxide device)
  • 3 runs of UV tower and 3 runs of movable 8 UV lamps device

• **Part 2: study factors that influence UV light effect**
  • 9 “test runs”
    • 6 with 8 UV lamp device
    • 3 with 4 UV lamp tower
  
  • Evaluation of duration of exposures
    • Between 4 minutes and 12 minutes
  
  • Evaluation of height of UV light source
    • Between 1’3” and 6’4” from ground (tower – 4 UV lamps)

• Locations
  • ER room (n=6)
  • ICU room (n=2)
  • ER patient bathroom (n=1)
Methods

• Stainless steel cubes contamination

  • Goals
    • For UVC system only
    • To palliate the ceiling effect associated with in situ contamination with RODAC plates
    • To control for orientation of the surface

  • Methods
    • A single surface contaminated with approx 10^7 CFU S aureus
    • Placement of contaminated stainless steel cubes in strategic locations in the room
    • Effectiveness of disinfection assessed by calculating the residual bacterial load on the test cube compared with an unexposed control
    • Sampling of cubes: by immersion in sterile bag and serial dilution on blood agar plates
Cube contamination used for UV light evaluation

• Impact of location of surface
• Impact of orientation of surface
• Impact of duration of exposure
• Impact of height of UVC source
Contaminated cubes in place
Analyses

• Effectiveness of disinfection method (Serial dilution technique)

  • Calculated as the difference between the residual bacterial load on the test surface and the bacterial load on the control (unexposed surface) expressed on a logarithmic scale

  • $\log_{10}$ reduction = $\log_{10}$ CFU control surface – $\log_{10}$ CFU test surface post disinfection
CFU assessed by 1:10 serial dilutions
Ceiling: 14/25
0.08
0.017
<0.001
0.026

Ceiling: 4/28

Ceiling: 5/19

N=3 rooms
19 surfaces
1 8 uv lamp unit in 3 successive locations in room
4 minutes total exposure

N=5 rooms
25 surfaces
3 uv light units simultaneously
7min32sec

N=5 rooms
28 surfaces

N=4 rooms
20 surfaces

Electrostatic sprayer

N=5 rooms
18 surfaces

Ceiling: 20/20

Ceiling: 6/18

N=3 rooms
18 surfaces
Hands-on time and Turnaround time
8 lamps UV system
Rooms: 24 and 33
Exposure time: 3 times 1min 34 (total: 4 minutes)
8 lamp UV light system
ER room
Exposure time: 3 x 4 minutes (total 12 minutes)
8 UV lamp system
Patient Bathroom
Exposure time: 1min 43 sec

Patient bathroom, 1min 43 sec exposure

- SS plate sink WC
- SS plate toilet handle
- Global
UV system (single unit)
Exposure time: 7 min 32 sec
Varying height of UV source

Impact of height of UV source

- Stretcher Hand rail (T)
- Stretcher Hand rail (F)
- Side Table
- Monitor Handle (F)
- Monitor Handle (T)
- Global

1'3" from ground vs. 6'4" from ground
Conclusions

• UVC system
  • Compared to manual disinfection and electrostatic pulverisers
    • More effective
    • Faster
    • Less variability

• Compared with H2O2
  • Less effective
  • Faster
UVC systems

- Effectiveness influenced by
  - Location of surface
  - Orientation of surface
  - Exposure time

- 8 lamp UV system
  - Location is at-odds with location of contamination in room

- Small 4 light tower system
  - Capacity to place it higher and to use multiple sources simultaneously could make it more interesting to healthcare system