

UVGI APPLIED DURING ORTHOPEDIC SURGERY AND THE RATE OF INFECTION

UVGI BASICS

Mercury Vapor lamps produce 253.7 nm radiation which breaks down the DNA and RNA of microorganisms, scrambling their genetic code so they cannot reproduce. Damage from ultraviolet exposure renders them effectively sterile and unable to grow or form new colonies.

Any microorganism, including bacteria, viruses, yeast, mold, and spores, that cannot reproduce are unable to cause infections.



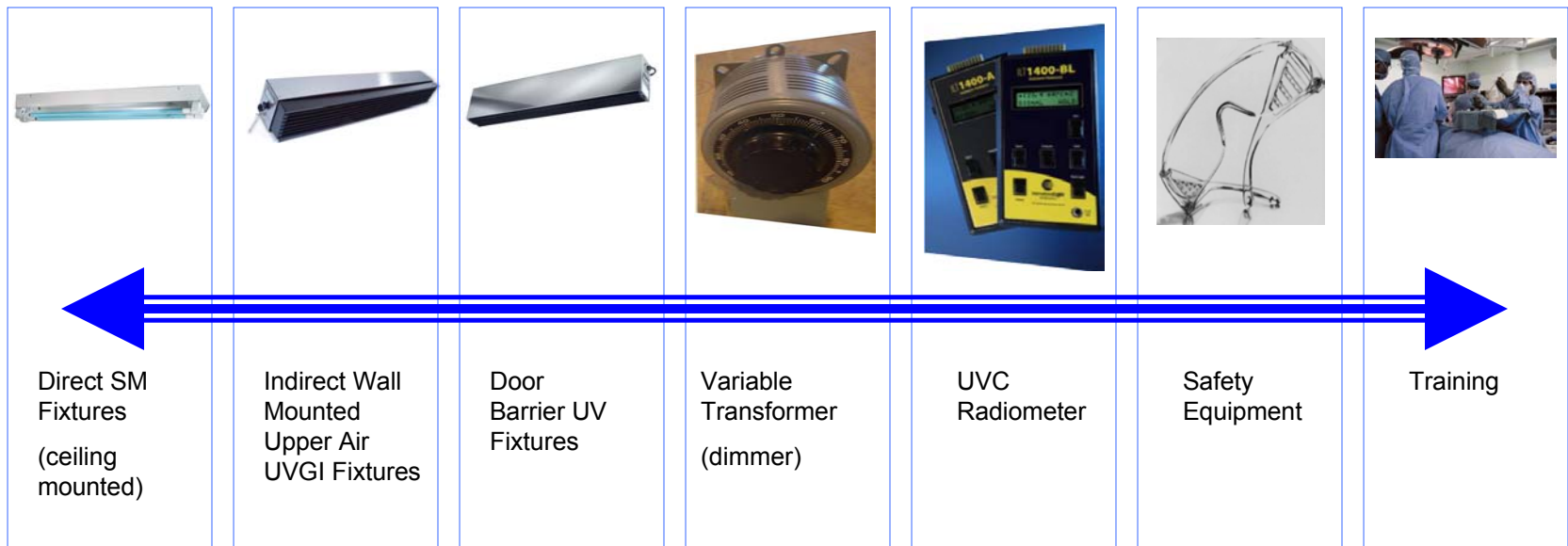
OVERVIEW

- ❖ Mechanics of how UVGI is used in an OR
- ❖ Two major studies: UVGI vs. no UVGI in orthopedic surgery suites
- ❖ UVGI used during total knee and hip replacement surgeries
- ❖ Second, most recent, study tracks one surgeon's results over 19 years



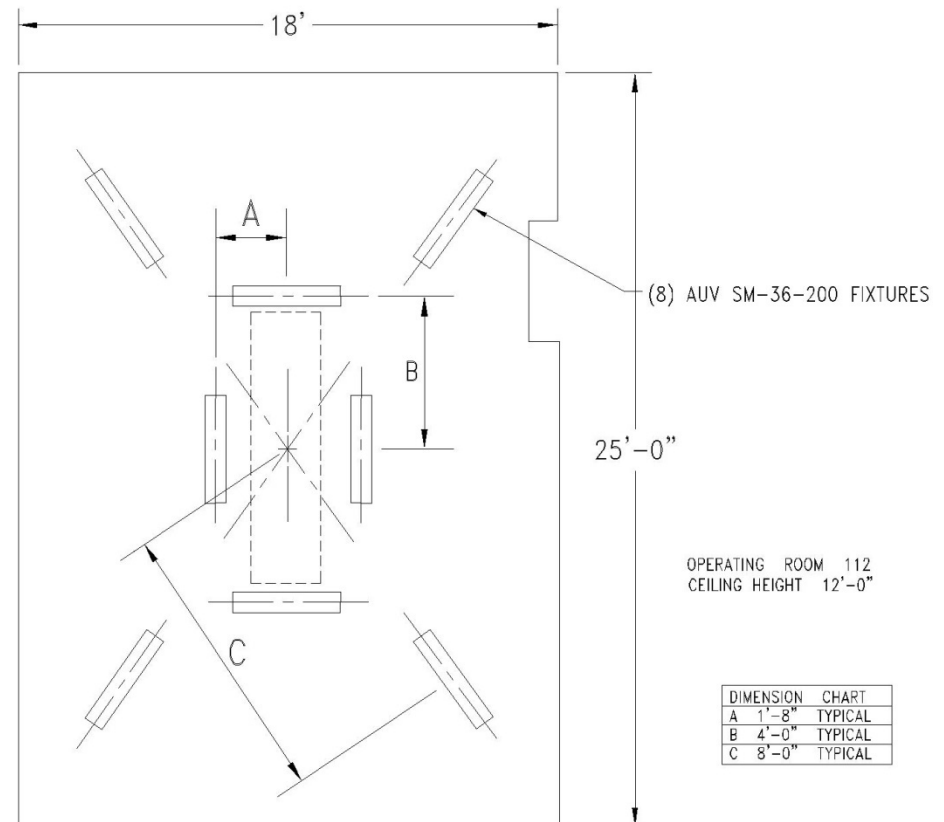
UVGI OPERATING ROOM EQUIPMENT "PACKAGE"

Example based on common OR layout.



SAMPLE PLACEMENT OF SM FIXTURES

- ❖ Ceiling mounted, direct fixtures are evenly spaced for maximum coverage to eliminate “shadowing”
- ❖ Vastly superior to portable devices used for the same application
- ❖ Fixtures used at lower intensity during procedures, turned on between procedures to max intensity
- ❖ Variable transformer (Variac) is used to control lamp intensity in these fixtures



UPPER-AIR UVGI INDIRECT FIXTURES

- ❖ Wall mounted 7.5' - 8' above floor
- ❖ Typically installed on opposite walls to cover room area appropriately
- ❖ Fixtures operate all full power at all times (even during procedures)



DOOR BARRIER FIXTURES

- ❖ Mounted over all access doors to operating suite
- ❖ Provide a protective “curtain” of UV energy
- ❖ Fixtures operate at full power during procedures
- ❖ Microorganisms are blocked from entering or exiting the operating theater when doors are opened



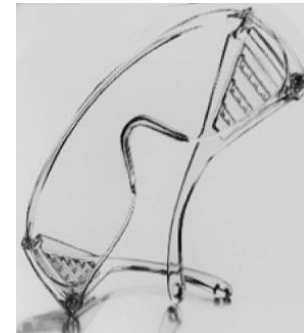
VARIABLE TRANSFORMER “VARIAC”

- ❖ Wired to Direct, Surface-Mounted fixtures
- ❖ Acts as a “dimmer” to dial down lamp intensity to desired level ($23 \mu\text{W}/\text{cm}^2$) at the surgical site
- ❖ Adjustability allows maximum lamp life use



RADIOMETER & SAFETY EQUIPMENT

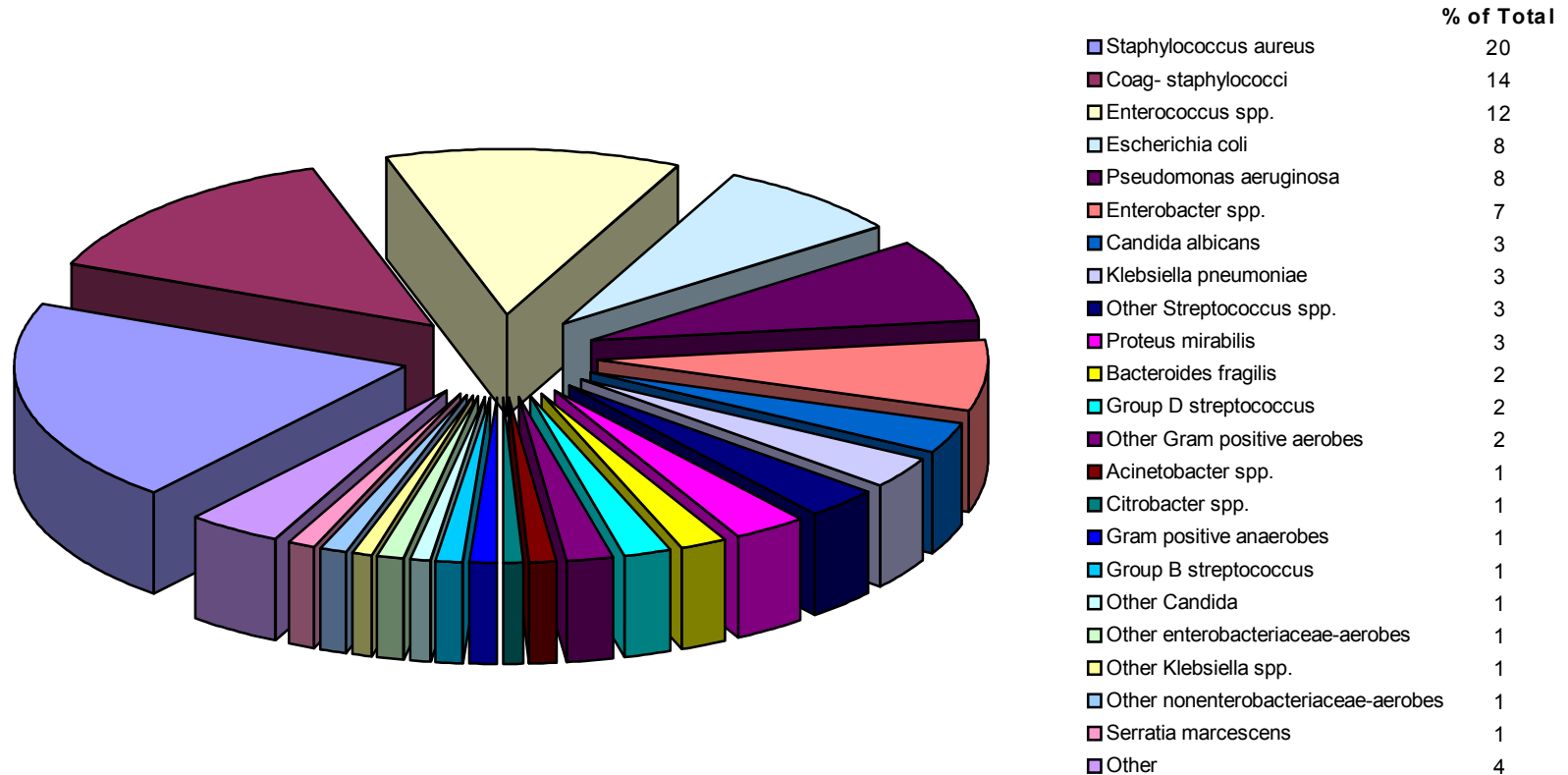
- ❖ Used to measure UVC energy at surgical site (knee, hip, etc.)
- ❖ Variac is dialed down to achieve desired intensity level ($23 \mu\text{W}/\text{cm}^2$) at the surgical site as indicated by radiometer
- ❖ UVC safety goggles and UV absorbing cream are provided with package to ensure safety of all personnel in suite
- ❖ On-site training of all personnel is the best safety precaution



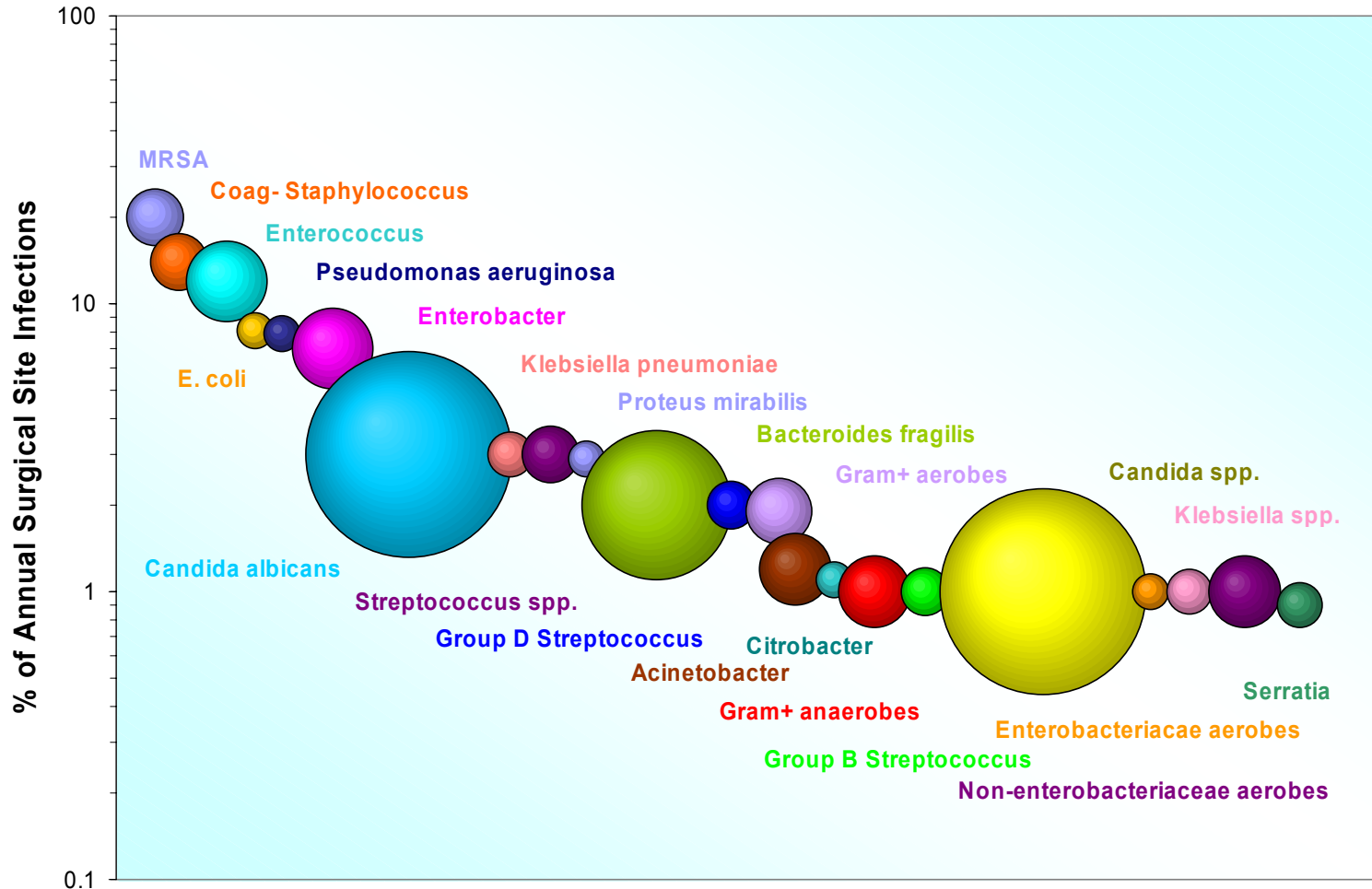
Potentially Airborne Nosocomial Pathogens

PATHOGEN	GROUP	ANNUAL CASES	PRIMARY INFECTION CAUSED	TYPE	MERV 13	UVGI D ₉₀
					Removal %	J/m ²
Influenza A virus	Virus	2,000,000	Flu, secondary pneumonia	Communicable	48	19.3
Measles virus	Virus	500,000	Measles (rubeola)	Communicable	38	(6)
Streptococcus pneumoniae	Bacteria	500,000	Lobar pneumonia, sinusitis, meningitis	Communicable	77	41.9
Streptococcus pyogenes	Bacteria	213,962	Scarlet fever, pharyngitis	Communicable	86	22.0
Respiratory Syncytial Virus	Virus	75,000	Pneumonia, bronchiolitis	Communicable	37	-
Varicella-zoster virus	Virus	46,016	Chickenpox	Communicable	37	39.3
Parainfluenza virus	Virus	28,900	Flu, colds, croup, pneumonia	Communicable	37	-
Mycobacterium tuberculosis	Bacteria	20,000	Tuberculosis, TB	Communicable	72	10.8
Bordetella pertussis	Bacteria	6,564	Whooping cough	Communicable	39	-
Rubella virus	Virus	3,000	Rubella (German measles)	Communicable	62	-
Staphylococcus aureus	Bacteria	2,750	Staphylococcal pneumonia, opportunistic	Endogenous	85	6.6
Pseudomonas aeruginosa	Bacteria	2,626	Pneumonia	Noncommunicable	60	9.7
Klebsiella pneumoniae	Bacteria	1,488	Opportunistic, pneumonia	Endogenous	74	42.0
Legionella pneumophila	Bacteria	1,163	Legionnaire's Disease, opportunistic	Noncommunicable	62	12.6
Haemophilus influenzae	Bacteria	1,162	Meningitis, pneumonia, endocarditis	Communicable	41	35.1
Histoplasma capsulatum	Fungal Spore	1,000	Histoplasmosis, fever, malaise	Noncommunicable	99	93.2
Aspergillus	Fungal Spore	666	Aspergillosis, alveolitis, asthma	Noncommunicable	99	1000
Serratia marcescens	Bacteria	479	Bacteremia, endocarditis, pneumonia.	Endogenous	72	10.0
Acinetobacter	Bacteria	147	Opportunistic/septic, meningitis	Endogenous	94	10965
Corynebacterium diphtheriae	Bacteria	10	Diphtheria, toxin produced.	Communicable	76	32.8
SARS virus	Virus	10 (China)	Severe Acute Respiratory Syndrome	Communicable	45	226.0
Haemophilus parainfluenzae	Bacteria	common	Conjunctivitis, pneumonia, meningitis	Endogenous	98	(38)
Burkholderia cenocepacia	Bacteria	common	Opportunistic	Noncommunicable	77	58.0
Cryptococcus neoformans	Fungal Spore	common	Cryptococcosis, cryptococcal meningitis	Noncommunicable	99	138
Chlamydia pneumoniae	Bacteria	rare	Pneumonia, bronchitis, pharyngitis	Communicable	65	-
Coccidioides immitis	Fungal Spore	rare	Coccidioidomycosis, valley fever	Noncommunicable	99	-
Nocardia asteroides	Bacterial Spore	rare	Nocardiosis	Noncommunicable	93	187
Nocardia brasiliensis	Bacterial Spore	rare	Nocardiosis	Noncommunicable	97	-
Alcaligenes	Bacteria	rare	opportunistic infections, endocarditis	Endogenous	81	-
Blastomyces dermatitidis	Fungal Spore	rare	Blastomycosis, Gilchrist's Disease	Noncommunicable	99	93.2
Burkholderia pseudomallei	Bacteria	rare	Melioidosis, opportunistic	Noncommunicable	60	(58)
Cardiobacterium	Bacteria	rare	Opportunistic infections, endocarditis	Endogenous	70	-
Moraxella	Bacteria	rare	Otitis media, opportunistic	Endogenous	94	11513
Mucor plumbeus	Fungal Spore	rare	Mucomycosis, rhinitis	Noncommunicable	99	171
Pneumocystis carinii	Fungal Spore	rare	Pneumocystosis	Noncommunicable	99	-
Rhizopus stolonifer	Fungal Spore	rare	Zygomycosis, allergic reactions	Noncommunicable	99	267
Burkholderia mallei	Bacteria	rare	Glanders, fever, opportunistic	Noncommunicable	74	(58)

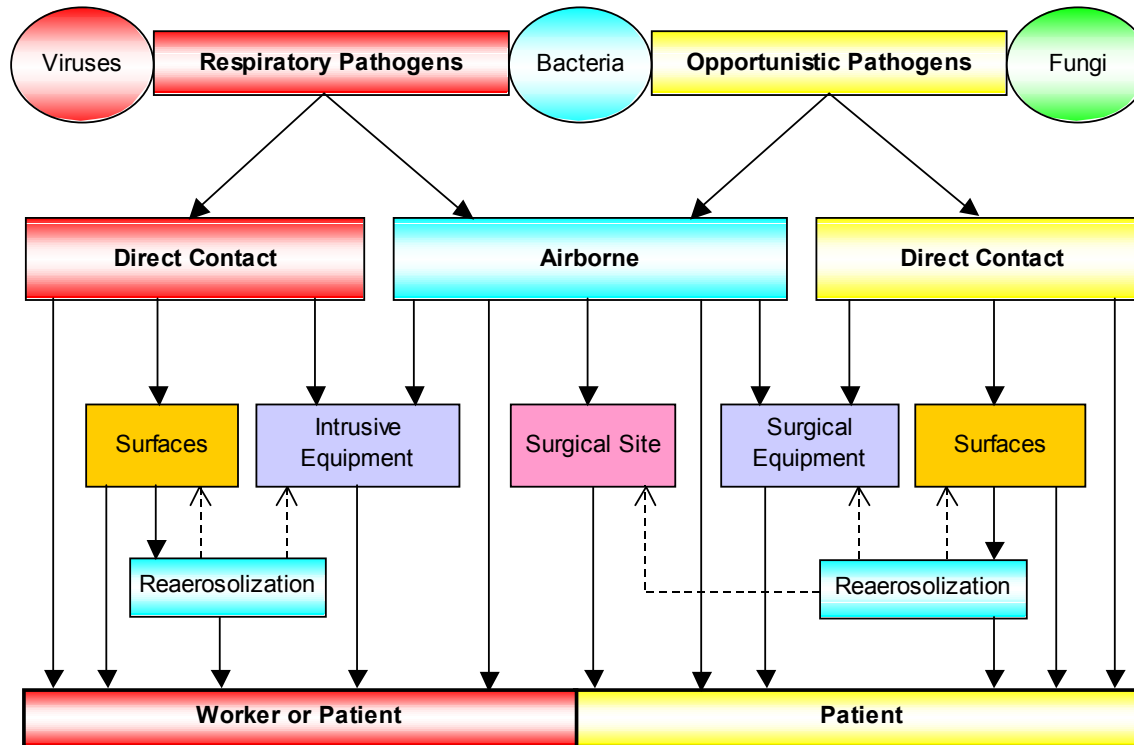
Causes of Surgical Site Infections



Occurrence & Relative Size of Surgical Site Infections



Transmission Routes of Surgical Site Infections



Nosocomial etiology can be complex, with multiple re-aerosolizations and equipment contamination affecting both patients and hospital workers

UVGI OPERATING SUITE PROCEDURE

❖ Prior to patient entering room

- Using UVC radiometer and Variac, proper set point is found on Variac dial to achieve 23 $\mu\text{W}/\text{cm}^2$ at surgical site
- This setpoint is noted for use during the procedure
- Radiometer stored
- Lamps turned up to full power for 5 - 10 minutes to bathe OR
- Lamps dialed down to previously established set point, then shut off at that level

❖ Patient brought in and prepped

- All exposed skin covered
- Eye protection for patient and staff
- Lamps re-ignited

❖ During Procedure

- Lamps remain on
- Procedure completed
- Patient removed and lamps turned off

❖ Ready for next procedure



THE STUDIES

DUKE UNIVERSITY & 2 MASSACHUSETTS HOSPITALS

- ▣ Duke had 10% post-op infection rate for “clean surgical wounds”
- ▣ UV lights installed
- ▣ 0.24% post-op infection rate in 5 years following UVGI installation
- ▣ 0.34% total post-op infection rate in the 26 years since UV installation
- ▣ 2 Mass. Hospitals dropped rate from 3.5% to 0.89% after installing UVGI in OR suites

ST. FRANCIS HOSPITAL

- ▣ Center for Hip & Knee Surgery
- ▣ Followed a single surgeon for 19 years and 5,980 total joint replacements
- ▣ 5 years without UV/14 with UV
- ▣ Infection rate dropped from 1.77% prior to UVGI installation to 0.57% after installation.
- ▣ 310% greater risk of post-operative infection without UVGI in the OR suite.

UVGI Effectiveness in Hospitals

Type	System	Location	Infection	Infection Cases		Decrease		Reference
				Before	After	Net	%	
Surgical Site Infections	Overhead Surgical Site UVGI	Duke University Hospital	SSI	5%	1%	4%	80%	Kraissl et al 1940
		Duke University Hospital	Hip arthroplasty infection	5%	0.5%	5%	90%	Lowell et al 1980
		NE Deaconess Hospital	SSI	15%	6.53%	8.5%	56%	Overholt and Betts 1940
		Infant & Children's Hospital, Boston	SSI	12.5%	2.7%	9.8%	78%	Del Mundo & McKhann 1941
		Watson Clinic, FL	Mediastinitis	1.4%	0.23%	1.2%	84%	Brown et al 1996
		St. Francis Hospital	SSI	1.77%	0.57%	1.2%	68%	Ritter et al 2007
AVERAGE REDUCTION							76%	
Airborne Infections	Upper Room UVGI	The Cradle, Evanston	Respiratory infection	14.5%	4.6%	9.9%	68%	Sauer et al 1942
		St. Luke's Hospital, NY	Respiratory infection	10.0%	6.6%	3.4%	33%	Higgins & Hyde 1947
		Livermore, CA Veteran's Hospital	Influenza epidemic	19.0%	2.0%	17.0%	89%	McLean 1961
		North Central Bronx Hospital	TB conversions among staff	2.5%	1%	2%	60%	EPRI 1997
		Home for Hebrew Infants, NY	Varicella epidemic	97%	0%	97%	100%	Wells 1955
		AVERAGE REDUCTION						

IMPLICATIONS

- ❖ Reduced infection rates mean:
 - Fewer post-op complications
 - Fewer deaths
 - Fewer repeated procedures
 - Lower costs to insurance companies and hospitals
 - Better PR for hospitals



Overhead UVGI at St. Francis Hospital

QUESTIONS & COMMENTS

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