

**ULTRAVIOLET RADIATION:**  
**IT'S BENEFICIAL EFFECT ON THE OPERATING ROOM ENVIRONMENT**  
**AND THE INCIDENCE OF DEEP WOUND INFECTION FOLLOWING**  
**TOTAL HIP AND TOTAL KNEE ARTHROPLASTY**

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**ABSTRACT**

AS A COROLLARY TO THE DEVELOPMENT OF TOTAL JOINT ARTHROPLASTY, THERE HAS BEEN AN INCREASED INTEREST IN THE PROBLEM OF WOUND SEPSIS FOLLOWING CLEAN RECONSTRUCTIVE SURGERY AND IN THE VARIOUS METHODS AVAILABLE TO DECREASE ITS LIKELIHOOD.

REDUCING THE NUMBER OF AIR-BORNE BACTERIA IN THE OPERATING ROOM BY ULTRAVIOLET RADIATION IS ONE AVENUE OF APPROACH AND IS CURRENTLY IN USE AT THE TWO BRIGHAM HOSPITALS. A REDUCTION IN THE DEEP WOUND INFECTION RATE FROM 3.5% TO 0.89% FOLLOWING ALL TOTAL HIP AND TOTAL KNEE REPLACEMENTS, WHETHER PRIMARY OR SECONDARY, AND FROM 2.6% TO 0.29% FOLLOWING PRIMARY REPLACEMENTS FOLLOWED ITS ADOPTION.

## ❖ULTRAVIOLET RADIATION❖

### IT'S BENEFICIAL EFFECT ON THE OPERATING ROOM ENVIRONMENT AND THE INCIDENCE OF DEEP WOUND INFECTION FOLLOWING TOTAL HIP AND TOTAL KNEE ARTHROPLASTY

Orthopaedic surgeons and their patients owe a great debt of gratitude to John Charnley for the many outstanding and imaginative contributions he has made to the field of surgery. Not the least of these contributions has been a resurgence of interest in the problem of infection that can follow clean operative procedures.

We are familiar with the story of total hip replacement at Writington and his successful effort to reduce the frequency of post-operative wound sepsis, from a high of 8.9% in 1961 to 1.3% in 1967 and to its current level of approximately 0.5% (2,3). He attributes the bulk of his success to the use of an ultra-filtered air enclosure with a high rate of air change and the simultaneous reduction of air-borne contaminants.

The significance of his work can scarcely be over-emphasized and the rapid proliferation of a wide variety of environmental controls unit's attests that his message has not been ignored.

If the principles of use outlined by Charnley are followed, there are essentially no hazards but there are some inconveniences. The interior of the unit can be noisy, communication may be difficult, the space is confining, spatial relationships are often confusing and it is easy to contaminate the surgical instruments by inadvertently touching them to the surface of the helmet worn as part of the surgeon's body exhaust systems. The variety of procedures, which can be done within it, is limited and the cost of the unit substantial.

Because the volume of reconstructive surgery is large at the two Brigham Hospitals, because many of our patients have multiple joint problems secondary to rheumatoid arthritis and many others are on immunosuppressives following renal transplant, it was imperative that we look into the matter of modifying our operating rooms as a source of contamination. Our two institutions are old; we anticipate a new building and costly modifications of our present buildings were not desirable if there existed an alternate effective method, convenient to use, safe, and modest in cost.

## ❖THE DUKE EXPERIENCE❖

At the suggestion of Carl Walter and Ruth Kundsinn of the Peter Bent Brigham Hospital, we were encouraged to consider the use of ultraviolet irradiation as an alternate method of reducing wound contamination by air-borne bacteria.

Investigations brought us into contact with Deryl Hart, former Chief of Surgery at Duke University, a man with a lifelong interest in the problem and prevention of wound sepsis. Having experienced, at Duke, during the period 1930-1935, an overall serious infection rate of 10% in clean operative wounds, and a striking rise of infection during the winter months requiring closure of all operating rooms for except emergency cases, Hart with Westinghouse Electric Corporation entered into a collaborative study which ultimately resulted in the installation of an overhead ultraviolet radiation system to be used during surgical procedures and to be left on when the operating rooms were empty (4,7).

During the first five years of their use the overall infection rate on clean cases dropped from 10% to 0.24%; on the orthopaedic service, it dropped from 16.5% to .74%. For the next 26 years, the overall infection rate was 0.34%.

This was at a time when many of the measures routinely used today in the care of surgical patients had not been introduced, including most of the antibiotics now considered commonplace. Hart's use of the ultraviolet irradiation in the operating room was not entirely free of potential problems. The patients and the members of the operating team needed proper shielding against direct exposure to the lamps; goggles were necessary to prevent conjunctivitis and a gown or topically applied suntan lotion was a necessary protection over exposed areas of skin to prevent erythema and peeling. The lamps required proper regulation and monitoring to produce the correct intensity of output. These inconveniences, however, were promptly outweighed by the benefits.

## ❖THE N.R.C. COOPERATIVE STUDY❖

In 1964 any general adoption of ultraviolet radiation to improve the operating environment ceased when an Ad Hoc Committee of the Committee on Trauma, Division of Medical Science, and National Academy of Sciences-National Research Council published a report of their findings on a study of ultraviolet radiation of the operating room (13).

There were five hospitals of major stature participating in the study with data being accumulated over a two-year period. There were two nearly equal groups of patients; one group whose operations were done in rooms equipped with conventional ultraviolet lamps the other in rooms equipped with dummy lamps. The infection rates of the two groups were then compared. In the conclusion of the study, it was stated that *"the only category of wounds that benefited significantly from the use of ultraviolet radiation was the 'refined clean' group, in which the post-operative infection rate was reduced from 3.8% to 2.9%. Even this beneficial effect, which was confined to a category representing only 19.2% of all infections analyzed, was lost in the overall experience, offset by an apparent detrimental effect of irradiation on non-clean wounds."*

One can interpret the data published in this study in various ways. Although the difference between the two rates was but .9% considering the large number of operations (14,854), it is statistically significant. If one looks at the five hospitals individually, the percentage of improvement ranged from 15% to 44% with the greatest improvement occurring in the hospitals where the infection rate was the lowest initially. For example, improving the infection rate in refined clean cases from 6.1% to .9% is a 44% improvement, as occurred in one hospital; improving the infection rate from 6.1% to 5.2% is an improvement of only 15%, as occurred in another, but the percent reduction in the first instance is .7 and in the second is .9.

There were 6,656 refined clean wounds studied in the N.R.C. Cooperative effect. One additional conclusion of the investigators was that thirty out of 128 infections observed among the 3,379 controls have been prevented by the intra-operative use of ultraviolet radiation. This finding was not included in the summary.

In 1972, Altemeier stated:

*"At a meeting of the American College of Surgeons Committee on the Control of Infections, of which I am chairman, we were given data that indicated that the cost of a post-operative wound infection on an average was \$7,000 per infection. This included not only the cost of hospitalization - the operative care, the increased material that was necessary, the physician's care, the nurses' salary - but also the cost of hospital insurance, loss of income from the patient's job during the illness, death benefits in the case of death, and the like. Multiplying the number of infections by \$7,000 gives a figure of greater than 9.5 billion, for the cost of infections for the year 1967, when the data was gathered (1)."*

Thus, thirty of 128 infections can become \$210,000 and a good deal of misery.

In 1968, Hart published a rebuttal to the N.R.C. Cooperative Study as well as his own further experiences with ultraviolet irradiation during operations (8). A comparison study was run at Duke University Hospital and the Durham Veterans Administration Hospital in which the senior and house staffs were common to the two hospitals and in which the same surgical and sterile techniques were applied. At Duke, ultraviolet irradiation was used; at Durham it was not. At Duke, the infection rate was 0.3%; at Durham it was 1.5%, yielding a comparison ratio of 1.5; the difference in rates was 1.2%.

There was agreement between Hart and the N.R.C. Cooperative Study report on ultraviolet radiation on the following four points:

- (1) *"The air of occupied operating rooms without ultraviolet radiation is contaminated with bacteria with varying degrees of pathogenicity, particularly staphylococci, which sediment continuously on all exposed surfaces."*
- (2) *Direct ultraviolet irradiation has a highly efficient bactericidal effect, which rapidly kills all types of organisms and will markedly reduce any air-borne bacterial contamination in the operating room."*
- (3) *With suitable protection, direct ultraviolet irradiation is safe for operating room personnel and patients."*
- (4) *With direct ultraviolet irradiation of the operating room of suitable intensity, there is a significant reduction in the number of post-operative wound infections following refined clean operations."*

Between the publication of Hart's early observations and the N.R.C. Cooperative Study, the few other reports, which appeared, supported him and were encouraging.

A study of Overholt and Betts in 1940 noted a post-operative infection rate of 13.8% after thoracoplasty without the use of ultraviolet radiation (10). In the two years following installation of the lamps, the rate decreased to 2.7%. Penfield reported the post-operative infection rate following all types of neurosurgical operations decreased from 1.1% to 0.4% after the Montreal Neurological Institute installed ultraviolet lamps in 1945 (12).

In November, 1969, Wright and Burke reported on the effect of ultraviolet radiation on post-operative neurological sepsis at the Massachusetts General Hospital, limiting their area of study to craniotomies and laminectomies, both of which were classified as refined clean procedures (18). Prior to the use of ultraviolet radiation, the infection rate after craniotomies was 5.3% and after spinal surgery was 4.1%. Over a thirty-six month period with the use of ultraviolet radiation in the operating room, the infection rate following craniotomies decreased to 0.7% and following laminectomies to 0.3%, a slightly less than 90% reduction of infection in the first category and better than 90% in the second.

### ❖SOURCES OF WOUND CONTAMINATION❖

It is generally agreed that the sources of pathogenic bacteria leading to wound infection may be endogenous or exogenous, and if the latter, may come from direct contact or indirectly through bacteria contaminating the air, but there is little agreement as to the relative importance of each of these sources. In reconstructive orthopaedic surgery, we are most concerned with exogenous sources. Our surgical wounds are in the category of clean wounds, i.e., those which are nontraumatic and uninfected, in which neither the bronchi, the gastrointestinal tract nor the genitourinary tract are entered. A subcategory of "refined clean" indicates non-use of drains at the time of closure.

In 1963, Walter, Kundsinn, and Brubaker, in a prospective bacteriological study of personnel, patients, and environment in 250 surgical procedures at the Peter Brent Brigham Hospital, reported that the presence of a disseminating carrier in the operating room though not in the 169 clean cases exposed (1.2%) (15). The same organism harbored by the carrier was also recovered from the aseptic field in fifty-six of the 169 procedures (33%). No other carrier of the specific phage type of Staphylococcus aureus responsible for the two infections was found.

In 1967, Walter and associates reported that of forty-three staphylococcal infections occurring on the surgical service of the Peter Bent Brigham Hospital over a five-year period, eighteen staphylococcal infections occurring in clean wounds could, based on phage typing, be identified with four disseminating carriers (16). By epidemiological inference, the twenty-five additional infections could be identified with the same carriers. Most of them were predominantly nasopharyngeal discharges.

As part of this same study, the incidence of Staphylococcus aureus carriers among operating room personnel was also reported. The lowest rate was among operating room nurses, 21% and the highest among orderlies, 71%. Surgeons and anesthesiologists were intermediate with 33% and 57% respectively. That there is air-borne dissemination of bacteria into clean operative wounds was an undeniable conclusion of their study. A potential source can readily be demonstrated by culturing the inside of a used facemask at the conclusion of an operative procedure (Fig. 1).

### ❖THE PROPERTIES OF ULTRAVIOLET LIGHT❖

Sunlight was first found to be bactericidal in 1877. Further study showed that wavelengths of the ultraviolet range were most responsible for this property and that the maximum bactericidal effect occurs at 2650 Angstroms on the electromagnetic spectrum (Fig. 2).

The mercury vapor lamp converts electrical input into the mercury resonance line (wavelength 2537A) (Fig.3). With almost 90% of the emitted ultraviolet energy from the bactericidal lamp on this line, it is highly efficient in destroying all types of viruses and vegetative bacteria. An intensity of twenty-five to thirty microwatts per square centimeter per second (cm<sup>2</sup>/sec) will kill 95% of the common vegetative pathogenic organisms in less than 3 minutes (6). Spores of bacteria and fungi are somewhat more resistant. It takes nearer twenty minutes to kill most all fungi, with the exception of aspergillus, which will survive sixty minutes of exposure.

Adverse side effects of ultraviolet radiation to personnel and patients, conjunctivitis and erythema of the skin, have already been noted. Repeated animal tests by Hart and Sanger showed that wounds exposed to twenty-five to thirty microwatts/cm<sup>2</sup>/sec from ten to ninety minutes heal at least as well as those of the controls (5). The effect of ultraviolet radiation upon wet and dry primate brains was not damaging to natural tissue using usual neurosurgical techniques, and as reported by Woodall et al, although somewhat faster changes of drying will occur in brain tissue on any prolonged exposure of the central nervous system, the usual precautions to prevent drying of tissue is preventative (17).

Hart reports no incidence of skin cancer among personnel working at Duke. Rusch was unable to produce malignancies in the skin of white mice exposed to 2537A radiation repeatedly and at high intensities (14). Skin cancer was produced if the wavelengths were confined to the area between 2900 and 3341A less than 2% of the output of bactericidal lamps.

High humidity levels have an adverse effect on the bactericidal properties of ultraviolet lamps and if the relative humidity level exceeds 60%, there is a precipitous drop-off in their usefulness (16) (Fig. 4). It is of the interest that no mention of the effect of humidity on the bactericidal power of ultraviolet radiation was made in the N.R.C. Cooperative Study. The average outside humidity in each of the cities where these five hospitals were located in over 70% and there is a question as to whether this missing observation is an additional clue to the negative results reported by the study.

### ❖THE BRIGHAM EXPERIENCE❖

Ultraviolet lamps were installed in two of the operating rooms of the Robert Breck Brigham Hospital in January of 1973 and in four of the operating rooms of the Peter Bent Brigham Hospital in August 1973. The installations were designed to produce, as nearly as possible, uniform radiation throughout each room. The intensity of output is monitored by IL 254 Germicidal Photometer which is compact in size, portable, run on batteries and easy to operate (Fig. 5). A rheostat which controls the output of the lamps, is adjusted to provide an intensity of radiation at the operative field of twenty-five microwatts/cm<sup>2</sup>/sec (Fig. 6). With the portable monitor, the intensity of radiation can be checked at any time, but after the first few minutes of operation, the intensity becomes quite steady for the remainder of the procedure. Eye shields, hoods, and protective cream such as UVAL® or SOLBAR® on exposed skin surfaces are used by all personnel in the room (11).

To assess our system's effectiveness in lowering air-borne and surface microbial populations, an experiment was carried out soon after installation. A non-pathogenic Escherichia coli was nebulized in two of the four rooms equipped with lamps and a Wells air centrifuge was used for volumetric sampling of the air with Trypticase Soy Agar as a recovery medium. Room temperature and humidity were monitored as well as ultraviolet radiation output; air samples were taken with and without the lamps illuminated. The concentration of the organisms recovered was 930/5 ft. 3 in one room, 310/5 ft. 3 in the other without the lamps illuminated. When the lamps were turned on, even though the nebulizer was not turned off, there was essentially instantaneous removal of 100% of the organisms in one room and 99.7% removal in the other.

Examination of the settling plates simultaneously employed with the Wells air centrifuge showed an average of forth-one viable organisms settling on every square foot of surface each minute without the lights. After fifteen minutes with the ultraviolet lamps on, no viable organisms were recovered on any of the settling plates.

A non-pathogenic organism was selected for this experiment, it being considered inappropriate to disperse pathogens in an operating room. Escherichia coli, the specific non-pathogen used, has essentially the same susceptibility to ultraviolet irradiation as many of the common pathogens including Staphylococcus aureus, Staphylococcus epidermidia, Proteus vulgaris, Pseudomonas aeruginosa, Streptococcus haemolyticus, and Streptococcus viridans (9).

With this favorable experiment behind us, we do not turn on the ultraviolet lamps until the operative procedure is about to start. This vastly simplifies anesthesia induction, which at both Brigham Hospitals is done in the operating room. It also eliminates the hazard of undue exposure to the patient's skin during the time for positioning prepping.

As recommended by Hart and the group at Dune, our personnel wear goggles or adequate eye shades, use appropriate protective clothing to cover their skin completely, or apply a benzophenone containing lotion to forehead, cheeks, under surfaces of the chin and back of the neck, if these areas are exposed (Fig. 6).

Three extensive bacteriological assays of the air in the operating rooms have been carried out during total hip replacement procedures: one with the ultraviolet lamps off during the operation and two with them on (Fig. 7, Fig. 8).

Volumetric air samples taken during the period of anesthesia induction, positioning, prepping and draping when our ultraviolet lamps are off, showed eighteen to twenty-one organisms/5 ft. 3. During the period the procedures were in progress, in twelve volumetric air samples taken adjacent to the operative wound, an average of nine organisms/5 ft. 3 were recovered in the room where the ultraviolet lamps were not used. In twenty-nine volumetric air samples taken in the rooms where ultraviolet lamps were used, zero to a maximum of five organisms/5 ft. 3 were recovered (Fig. 9). Only two of the twelve samples had five or fewer organisms where there was no ultraviolet radiation, whereas twenty-six of the twenty-nine samples where ultraviolet radiation was used had five or fewer organisms ( $P=.02$ ). The procedures performed in the presence of ultraviolet irradiation were more difficult. Each consumed six hours of operating time and involved the taking down of old fusion's; one secondary to a tuberculosis hip spontaneously fused since childhood and the other, the releasing of a hip surgically fused for degenerative joint disease.

At the end of the operative procedure, after the wound was closed, the drapes were removed and the patient wheeled out, air counts increased spectacularly in the room with no ultraviolet irradiation to an average of forty organisms/5 ft. 3, while in the irradiated room with similar activities, even though the lamps were turned off at the time of wound closure completion, only two organisms/5 ft. 3 were recovered, indicating that air-borne microorganisms did not accumulate during surgery in the presence of ultraviolet irradiation.

Examination of the fall-out plates showed that in the room without irradiation four to eight viable organisms could be recovered /ft. 2/min. throughout the procedure in contrast to 0.2 viable organisms/ft. 2/min. with irradiation, a 95% reduction.

The accumulation of viable organisms on horizontal surfaces in the operating room was assessed by the use of Radac Agar Contact plates. In the absence of ultraviolet irradiation both *Pseudomonas* and *S. aureus* were readily recovered.

The bacterial count on an impression taken from an operating room light went from zero at the start of the procedure to forty-two at the end of it when there was no irradiation. With irradiation, no such increase was seen; it was zero at the start and zero at the end. Only one high Rodac plate count was obtained in each of the two-irradiation rooms; one was at the base of the operating table, almost at the floor level, an area totally shielded from the lights and thirty-one organisms accumulated on this plate. The other was from the base of an operating room lamp similarly shielded and forty-seven organisms were obtained. Of the eighteen other plates exposed, they showed no organisms and the remaining eight showed an average of 2.5 organisms. Instrument tables, the electrocautery, the anesthesia cart, open shelves and the floor were the sources of the other samples. No *Staphylococcus aureus* was recovered in the irradiated rooms but in two locations, it was recovered in the non-irradiated room.

### ❖DEEP WOUND INFECTIONS❖

We have reviewed through November of 1974 the problem of deep wound infection occurring after total hip and total knee replacements performed since July of 1970 in the two Brigham Hospitals.

690 total hip and total knee replacements were done at the two institutions prior to the installation of the ultraviolet lamps. Twenty-four deep wound infections followed an incidence of 3.5%. 786 total hip and total knee replacements have been done since the installation of the lamps and seven deep wound infections followed an incidence of 0.89% (Table I). This is a significant at the .01 level by the X<sup>2</sup> test.

If one then subdivides these groups into cases where previous surgery has or has not been performed, in the pre-ultraviolet irradiation series, 583 primary operations were followed by fifteen infections (2.6%) and 107 operations on previously operated joints were followed by nine infections (8.4%). After ultraviolet irradiation came into use, the infection rate dropped in both groups to .29% and 5.5% respectively. The adverse effect of previous surgery on the involved joint remains apparent, however, in both the pre-ultraviolet and post-ultraviolet series. At the RBBH since the ultraviolet lamps were installed, there has been but one deep wound infection in a hip or knee undergone surgery for the first time, in the last 600 cases - an incidence of .17%. Although there has also been but one deep wound infection in primary total joint replacements at the PBBH since ultraviolet irradiation came into use, the total number of such cases is ninety-six and the incidence is 1%. This particular patient had his total hip replacement delayed ten days while he underwent treatment for an ectopic dermatitis.

Of the twenty-four infected cases occurring prior to the use of ultraviolet irradiation, eight were early infections, occurring within three months of operation, and sixteen were late. Fifteen patients had had no previous surgery on the involved joint and nine had had previous surgery. Of these, one had had previously infected surgery.

Of the seven infections occurring after installation of the lamps, two were early and five were late. Two had had no previous surgery and five had had previous surgery but none had had previously infected surgery.

There has been a higher incidence of infection after total knee replacement than after total hip replacement at both institutions (Table II). Prior to the installation of the lamps, sixty-nine total knee replacements were followed by six deep infections (8.7%). Of these, sixty-four replacements without previous surgery were followed by five infections (7.8%). Five with previous surgery were followed by one infection (20%). After the installation of the lamps, 299 knee replacements were followed by five deep wound infections (1.7%). Of these 289 without previous surgery were followed by one infection (0.35%) and ten with previous surgery were followed by four infections (40%).

Of 621 total hips done prior to ultraviolet irradiation eighteen (2.9%) developed deep wound infections (Table III). Of these, 519 had not had previous surgery and ten (1.9%) developed deep wound infections. After the installation of the lamps, 487 total hip replacements were followed by two deep wound infections (0.41%). Of these, 407 had not had previous surgery and one infection followed (0.25%).

The series is a longitudinal one and as such is subject to this objection. More late infections may appear in either group though they are more likely to appear in the latter. The maximum follow-up period in this group is two years and four months; the maximum, six months. Of our twenty-four late infections, four appeared as long as nineteen, twenty-three, twenty-four and thirty-six post-operatively.

The nine-member full time visiting staff of the two hospitals has changed little in the four-year experience under review. The residents and ancillary personnel are constantly changing.

Systemic and topical antibiotics were used at each hospital throughout the entire period of observation and no changes were made in the regimen. Intravenous cephalosporin during and for two days after surgery is used at the PBBH and intravenous oxacillin accompanied by an initial dose of streptomycin is similarly used at the RBBH. Topical Bacitracin and Polymyxin B are used at the RBBH and topical Bacitracin, Polymyxin B, and Neomycin is used at the PBBH. Impervious disposable gowns and drapes re used at the RBBH and cloth gowns at the PBBH. The occurrence of infection does not differ significantly between the institutions.

The financial cost of the hospitals for this equipment was approximately \$1500 per room, including the portable monitoring equipment, the rheostats used to control the lights, and their installation.

We have had only three complications attributable to ultraviolet radiation and each was a case of conjunctivitis secondary to lack of proper eye shielding by members of the operating team. There has been no problem for the patients in over 1500 total hip and total knee replacement procedures.

In summary, we would agree wholeheartedly with Hart and the group at Duke, in their contention that the use of ultraviolet radiation during operative surgery will effectively reduce the threat of bactericidal contamination of the operative wound and the observed incidence of post operative deep wound infections following refined clean operations.

The system is simple to install, and was done at both hospitals by our own maintenance personnel with the technical advice of the supplier. The lamps caused no inconvenience to others who wish to use the rooms without them, since they may be turned off at will. They do not occupy any space previously used for other purposes. No space outside the operating rooms is sacrificed for supporting equipment and the cost is vastly less than the cost of installing unidirectional airflow.

The hazards of using ultraviolet radiation in the operating room have been defined and well known for years and the prevention of complications is relatively simple.

We would recommend that all surgeons considering the employment of one or another of the available techniques currently in use for reducing bacterial contamination in the air look seriously at Deryl Hart's contribution before making a final decision.

Figure 1

**WITHOUT UV**

In an occupied operating room during a total hip replacement, settling plates in the four corners of the room and on the anesthesiologists' table, show 3-8 viable organisms settling on every square foot of surface throughout the OR, throughout the operation, with every minute of time.

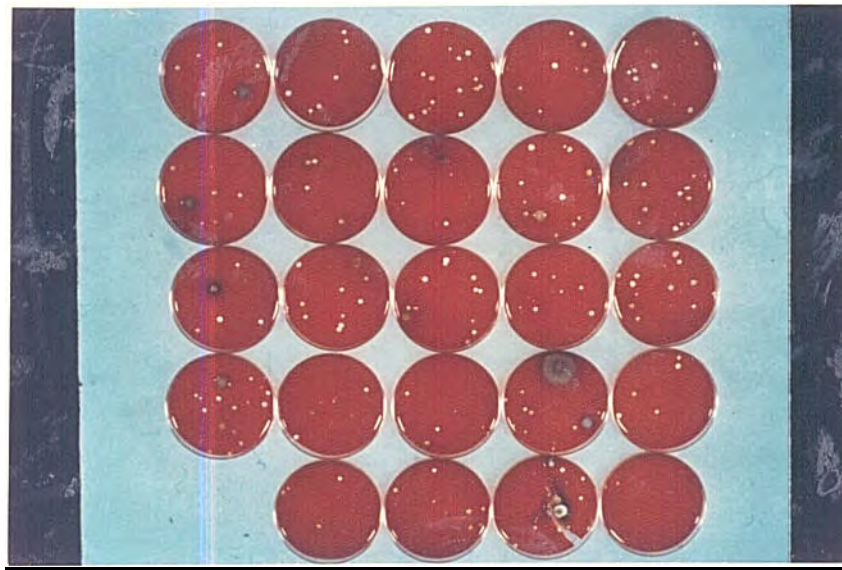


Figure 2

**WITH UV**

The UV lights were off during the period of anesthesia induction, prepping and draping. They were on for the net four and three quarter hours during conversion of a hip fusion done in childhood to a total joint arthroplast. The final set of plates during patient transfer and cleaning of the room does not show the high counts occurring during the first hour of greater occupancy. The next to last set of plates had fifteen minutes of no UV.



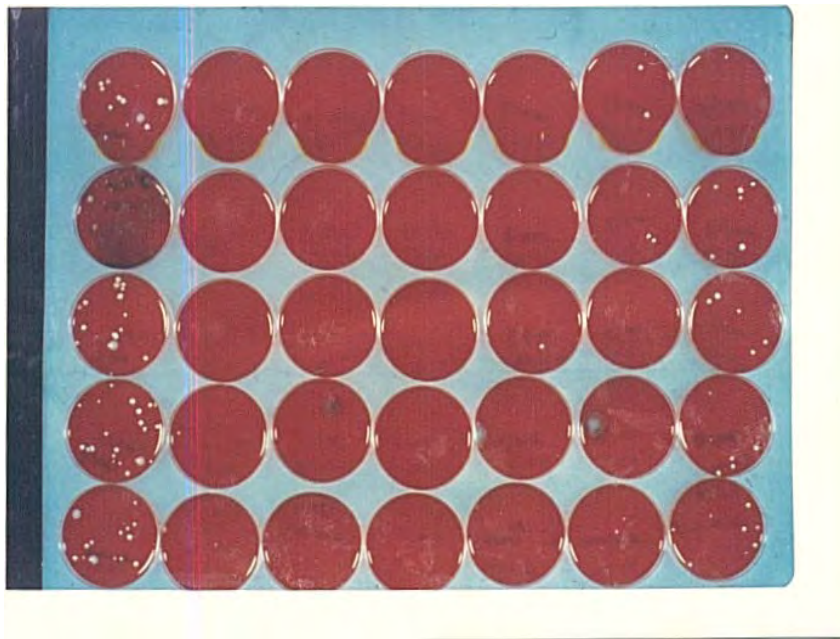


Figure 3

The inner surface of a surgeon's facemask was pressed onto an agar plate after four and one half-hours of use. Most of the organisms re staph albus although a few are staph aureus. A facemask is an averaging device.

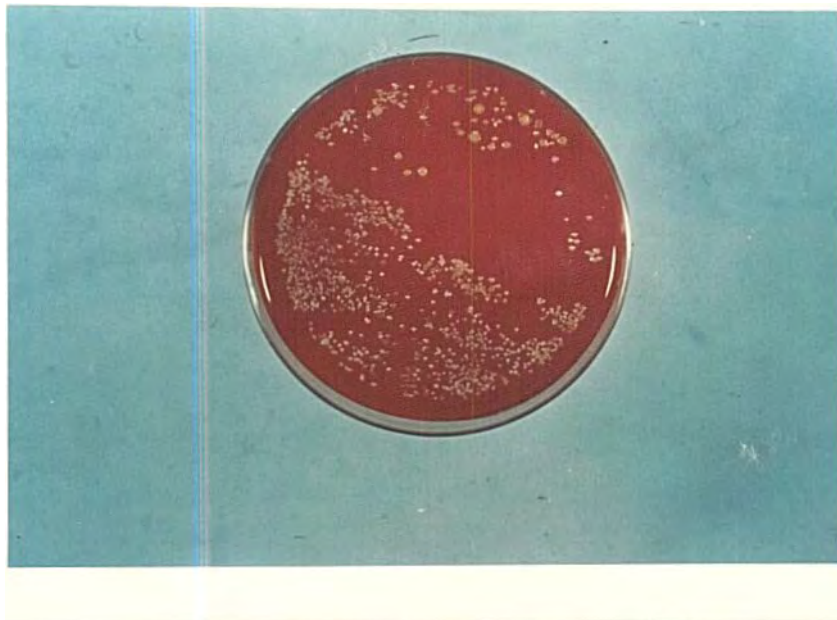
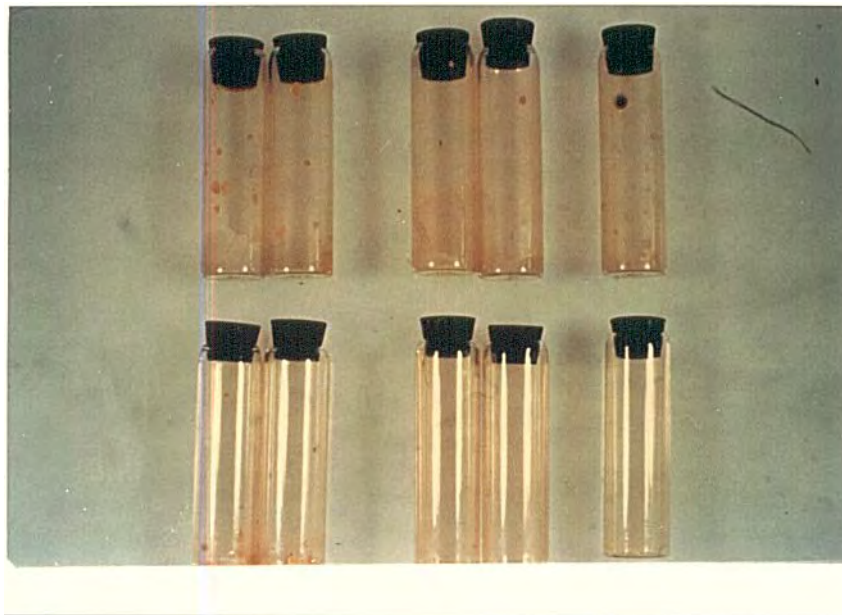


Figure 4

Volumetric air samples were taken at the wound site with Wells Air Centrifuge during two different total joint arthroplasties. The top row shows 18 to 20 organisms per 5 ft 3 of air without UV, dropping to 9 when the room became quieter. With UV the count dropped to 5. Several of the samples were bacteria free when UV was used.



(Color prints of Figures 1, 2, 3, and 4 available upon request from  
American Ultraviolet Company)

- TABLE I** Deep wound infections. Combined experience.  
 Peter Bent Brigham and Robert Breck Brigham Hospitals  
 Total hip and total knee replacements  
INFECTIONS - HIPS & KNEES (PBBH-RBBH)

PRE UV

|                      |               |      |
|----------------------|---------------|------|
| Prim. Op. 583        | Inf. 15       | 2.6% |
| Prev. Op. <u>107</u> | Inf. <u>9</u> | 8.4% |
| 690                  | 24            | 3.5% |

WITH UV

|                     |               |       |
|---------------------|---------------|-------|
| Prim. Op. 696       | Inf. 2        | 0.29% |
| Prev. Op. <u>90</u> | Inf. <u>5</u> | 5.5%  |
| 786                 | 7             | 0.89% |

- TABLE II** Deep wound infections.  
 Peter Bent Brigham and Robert Breck Brigham Hospitals  
 Total knee replacements  
INFECTIONS - KNEE (PBBH-RBBH)

PRE UV

|                    |               |      |
|--------------------|---------------|------|
| Prim. Op. 64       | Inf. 5        | 7.8% |
| Prev. Op. <u>5</u> | Inf. <u>1</u> | 20%  |
| 69                 | 6             | 8.7% |

WITH UV

|                     |               |       |
|---------------------|---------------|-------|
| Prim. Op. 289       | Inf. 1        | 0.35% |
| Prev. Op. <u>10</u> | Inf. <u>4</u> | 40%   |
| 299                 | 5             | 1.7%  |

- TABLE III** Deep wound infections.  
 Peter Bent Brigham and Robert Breck Brigham Hospitals  
 Total hip replacements  
INFECTIONS - HIP (PBBH-RBBH)

PRE UV

|                      |               |      |
|----------------------|---------------|------|
| Prim. Op. 519        | Inf. 10       | 1.9% |
| Prev. Op. <u>102</u> | Inf. <u>8</u> | 7.8% |
| 621                  | 18            | 2.9% |

|                     |               |       |
|---------------------|---------------|-------|
| WITH UV             |               |       |
| Prim. Op. 407       | Inf. 1        | 0.25% |
| Prev. Op. <u>80</u> | Inf. <u>1</u> | 1.3%  |
| 487                 | 2             | 0.41% |

#### GENERAL INFORMATION ON PBBH EQUIPMENT FOR SAFE USE OF UV LIGHTS DURING SURGERY

##### Ultraviolet Lighting Fixtures

##### Photometer

AUV-1400A Germicidal Photometer from:

##### Eye Shields

SAF015 Safety faceshield

Sam Guzman, Sales Manager  
American Ultraviolet Company  
290 Schooley's Mountain Road  
Building 3A -Suite 2  
Hackettstown, New Jersey 07840  
1.908.684-3290 ~ phone  
1.908.684-3295 ~ FAX  
[SGuzman@auvco.com](mailto:SGuzman@auvco.com) ~ e-mail

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