Effect of Ultraviolet Radiation on Postoperative Neurosurgical Sepsis

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Ultraviolet radiation during clean surgical procedures was introduced 30 years ago as a method of cleansing air in the operating room. Pioneers with this tactic used an intensity of between 18 and 30 μW/sq cm at the operative site and claimed that the incidence of infection in clean surgical wounds fell significantly. Most hospitals have remained reluctant to accept the value of this technique, and medical literature contains conflicting statements on its value. The cumbersome garb required of the operating teams has been perhaps a major reason that this method has never become widely used. Early investigators emphasized that this technique was of value only in the so-called "clean" operative wounds and that the risk of infection was not significantly altered when massive bacterial contamination was already present or occurred during the procedure (as by opening alimentary or respiratory passages). The low incidence of infection reported by the few centers that have used this system has not been obtained by any other group with any other technique. Many surgeons have continued to regard a 2% to 5% incidence of clean surgical wound infection as acceptable.

Background

Following observations by Downes and Blunt and Roux that sunlight could be bacteriocidal, Barnard and Morgan in 1903 showed that waves of the ultraviolet range were responsible for this property. Further studies have shown that the maximal bacteriocidal effect was obtained in the range of 2100 to 2800 Å which was below the reported carcinogenic wave lengths of 2900 to 3341 Å.

With improved methods for cleansing the operative site and protection against infection from surgeons' hands and instruments, it became apparent that airborne bacteria settling in surgical wounds during operation played a major role in subsequent sepsis. A major source of these organisms was traced to the nasopharynx of personnel in the operating theater. Modern methods of ventilation and air filtration have resulted in a diminution of contamination from this source and a lesser incidence of clean wound infection. Nevertheless these results have not equalled those reported by centers that have persisted in the use of ultraviolet radiation during operation.

In 1936 Wells and Wells documented the fact that ultraviolet irradiation led to a marked reduction of airborne bacteria. That same year Hart began a clinical trial with this technique in the operating rooms at Duke University Hospital. He emphasized that the marked decrease in post-surgical sepsis was limited to clean operations. In the years prior to 1936 that hospital had had a clean case infection rate of approximately 10%; with ultraviolet irradiation of the operating rooms during surgical procedures this fell to 0.6%. Surprisingly few general surgical services have tried this technique. One of the few other clinical trials that included a significant number of cases was that reported by Overholt and Betts. Noting after thoracoplasty a postoperative infection rate of 13.8% in 1936, they had ultraviolet lamps installed. In the next 2 years this level fell to 2.7%. Subsequent data were not reported. Except for this study and Hart's continuing interest, there were no other significant studies on ultraviolet irradiation of general surgical operating rooms until 1964.

The recent cooperative study sponsored by the National Research Council was conducted in five major hospitals over a 30-month period and showed no definite advan-

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tage with the use of ultraviolet radiation during operations of all types. However, an analysis of the data obtained at these centers suggests that infections were one-third less in the so-called “refined-clean” group of cases when performed under ultraviolet lamps than in the control groups. There was, however, no beneficial effect in contaminated cases.

Neurosurgical Use of Ultraviolet Radiation

Intracranial operations differ in many ways from most general surgical procedures. Although clean extracranial surgical operations on the head and neck carry in general a very low risk of operative wound infection, the incidence of sepsis following craniotomy has remained significant at most hospitals. Large dead spaces must often be left in the intracranial cavity following removal of tumors, hematomas, etc., and unlike operations elsewhere in the body it is impossible to obliterate these spaces. Areas of devitalized tissue must sometimes be left; for example, debridement of damaged brain cannot be as extensive as is good practice with most other tissues. Potential dead spaces between bone and flap and dura, and between pericranium and galea, often fill with hematoma in the postoperative period despite the most meticulous surgical technique. Such circumstances would favor growth of bacteria that had fallen into the operative wound. Finally, the length of intracranial operations is greater than most general surgical procedures. These factors set a favorable background for wound sepsis.

Two other neurosurgical services on this continent have continued the use of ultraviolet radiation in operating rooms. Each group has felt this technique was of undoubted value in lessening the risk of postoperative sepsis. Woodhall, et al., utilizing Hart’s techniques developed at the same institution (Duke University Hospital), but reducing the intensity to 16 \( \mu \text{W/sq cm} \), were able to reduce the incidence of sepsis following 1228 craniotomies to 1.05% and comparable complications of spinal operations to 1.9% (25 infections in 1334 laminectomies) during the years 1938 to 1948. Before the use of the ultraviolet technique, the over-all incidence of neurosurgical infections following clean cases was 9%. Later Odom, et al., again reviewed the Duke experience with operations performed under ultraviolet radiation. Over the 17-year period from 1941 to 1958 during which ultraviolet lamps were used there were 0.4% infections in 2342 craniotomies with only one death due to sepsis. Following 3774 laminectomies there were 21 (0.6%) infections and no fatalities.

Penfield, in a personal communication to Woodhall, reported that the use of ultraviolet lamps in operating rooms at the Montreal Neurological Institute resulted in a decline in the incidence of postoperative infection following neurosurgical operations of all types, from 1.1% (25 of 2313 cases from 1942 to 1945) to 0.4% (10 of 1753 cases from 1945 to 1948). Rasmussen has stated that in the past 20 years the over-all infection rate following neurosurgical cases has remained at the low level of 0.4%. It has been their practice in most cases to use ultraviolet lights only during opening and closing stages of the procedure and to extinguish them when the brain is actually exposed. As a rule the lights have been kept on over instrument tables during the entire operation; however, a few surgeons in their group have not used them at all. Nevertheless this intermittent usage has been accompanied by one of the lowest rates of postoperative sepsis reported by any neurosurgical service.

Molina and Ognissanti have recently attested to the value of ultraviolet radiation in neurosurgical operating rooms in South America. They have not, however, cited their exact data.

The scant data available from neurosurgical centers suggest that the usual incidence of bacterial infection following clean intracranial operations is between 3% and 6%. Odom, et al., have studied the effect of ultraviolet radiation (2537A) at an intensity of 16 \( \mu \text{W/sq cm} \) on the cerebral cortex of dogs. These observers concluded that dilatation of pial vessels and swelling of cerebral hemispheres occurred sooner under ultraviolet light than in control animals whose brains were exposed to room air. Moreover, after 3 hours of exposure of the canine brain to ultraviolet radiation, there were spontaneous subpial hemorrhages and microscopic evidence of neuronal damage.
Experience at the Massachusetts General Hospital

At the Massachusetts General Hospital, various factors possibly related to postoperative neurosurgical wound infection have recently been evaluated. From 1952 to 1965 the clean-case infection rate following craniotomy was 5.3% (137 of 2583 operations). The yearly rates of postoperative craniotomy sepsis ranged from 2.0% in 1965 to 9.4% in 1956 (Fig. 1). The sepsis rate following spinal surgery has been somewhat less, or 4.1% (85 of 2085 operations). Yearly variations have been from 0.9% in 1952 to 7.8% in 1954. Two standard neurosurgical procedures, craniotomy and laminectomy, have been considered in this study. These are the most commonly performed neurosurgical operations, and almost all are so-called clean cases. Contaminated procedures for abscess, compound fractures, and missile wounds have been deleted from the figures given above.

In these studies it was apparent that the duration of the operation was directly related to the incidence of sepsis. Craniotomies lasting 1 hour had an infection rate of 2% whereas those requiring 6 or more hours had a rate of sepsis exceeding 10%. Reexploration of the same surgical wound also increased the incidence of sepsis. Both of these factors would increase airborne contamination at the operative site. These studies have also shown that the various techniques for wound closure, administration of preventive antibiotics postoperatively, or use of topical antibiotics at the time of surgery had no significant effect on the subsequent incidence of infection.

The term infection as used in this report implies true bacterial infection arising at the operative site, confirmed in most instances by identification of causative organisms. Among the infections are postoperative wound abscesses, extradural abscesses, osteomyelitis of skull or spine, disc space infections, brain abscesses, and meningitis. The single exception in this group in which causative bacteria have not been identified was disc space infections, which were often treated without reexploration or drainage. Entities such as undefined swelling or hyperemia of the wound, fever of unknown cause, and aseptic meningeal reactions have not been counted as infections.

In January, 1966, ultraviolet lights with
an intensity of 35 μW/sq cm at the level of the operating table were installed in the neurosurgical operating rooms at this hospital. There have been no other changes in technique except for the more extensive masking and gowning required for the protection of operating room personnel. Since then there has been a precipitous fall in postoperative sepsis (Fig. 1). For the 36-month period ending in December, 1968, 1851 clean operative cases were performed under ultraviolet radiation. In 669 craniotomies there were 5 (0.7%) infections; there were 2 (0.3%) infections following 579 laminectomies and 3 (0.5%) infections after 603 miscellaneous neurosurgical procedures. Included in this last group were stereotaxic operations, burr holes, peripheral nerve procedures, and cervical carotid operations. Staged carotid occlusions, ventriculo-venous shunts, cranioplasties, and procedures that require implantation of electrodes for long periods have been deleted because of the large foreign bodies that have been left in operative wounds and the difficulties in sterilizing these instruments. There have been no fatalities due to infection over this period. Three of the five postoperative craniotomy infections followed use of subdural drains for 48 hours; another occurred in a patient who developed excessive bleeding tendency after administration of low molecular weight Dextran, necessitating two re-explorations of the wound for hematoma removal in the early postoperative period. The infections complicating other neurosurgical procedures in this period were superficial abscesses and created no significant morbidity.

Use of ultraviolet radiation in the operating room does require protective goggles and hoods for members of the operative team. Nevertheless, complications have been minimal. A few cases of hyperemia of skin and conjunctival irritation reported by operating room personnel have been attributable to inadequate protection. These have been minor and in most instances have cleared within a few hours. Two physicians sustained corneal ulcerations as a result of neglecting to use protective goggles or side shields. Although extremely painful, these healed within 1 to 2 days and there was no permanent damage. There have been no indications of harm to the patient such as impaired function of the nervous system or delayed wound healing.

Discussion

Medical literature contains conflicting statements on the value of ultraviolet radiation during operation in reducing the incidence of postoperative wound infection. Many of these statistics combine tabulation of contaminated cases with clean surgical cases. Available data suggest that so-called clean cases, namely those with no preoperative contamination or intraoperative bacterial contamination, show the greatest benefit from this tactic. Preliminary studies begun at this hospital in January, 1966, have been encouraging. The possibility remains, however, that the apparent benefit is due in part to the more thorough gowning and masking of all individuals in the operating room as well as to some reduction in the number of personnel involved. Nevertheless, we believe that ultraviolet irradiation of the operating room during long, clean neurosurgical procedures has been a valuable factor in reducing the incidence of sepsis.

Summary

Ultraviolet radiation of neurosurgical operating rooms has been evaluated at the Massachusetts General Hospital for a period of 36 months. With the introduction of this system the clean case infection rate fell to a fraction of its former level. Although other factors may be involved, these data as well as those from other centers suggest that ultraviolet radiation used during operation is an effective adjunct reducing sepsis in prolonged clean surgical procedures.

References

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