ULTRAVIOLET RADIATION AS AN ADJUNCT IN THE CONTROL OF POST-OPERATIVE NEUROSURGICAL INFECTION. II CLINICAL EXPERIENCE 1938–1948*†

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IN 1936, HART described the use of ultraviolet radiation for the reduction of postoperative infection from air-borne bacteria in the operating room.[1] In subsequent publications, Hart and his associates have presented in considerable detail the bacteriologic and clinical aspects of this problem in the field of general surgery. Only preliminary clinical studies were conducted among neurosurgical cases.[1k] This report will include our total experience with the use of ultraviolet radiation as an adjunct in the control of potential postoperative infection among 3,019 clean neurosurgical cases during the time period between January, 1938, and July, 1948. A preceding publication has described the effect of the exposure of atmospheric air plus ultraviolet radiation upon the brains of experimental animals.[2] No structural alterations were demonstrated in these studies that precluded the use of ultraviolet radiation upon the human brain nor has clinical experience suggested any untoward reaction in the exposed cortex when that structure is protected by the usual neurosurgical methods.

Although the complicated problem of postoperative infection has been examined at length by general surgeons, there is by comparison little direct experience recorded in our neurosurgical literature. Cairns, almost alone in his study of this field, has demonstrated without much doubt that neurosurgical postoperative infection does exist and represents a formidable obstacle to the attainment of consistently good technical results. The material of his first report[3] and a second review of later clinical investigations[4] may be summarized as follows:

	Operations	Infections	Deaths
1927–1938	968	?	23
May 1938–November 1944	1169	51 (4.4%)	13
December 1944–March 1947	670	6 (0.9%)	0

After November, 1944, Cairns began the prophylactic local use of a mixture of penicillin and sulphamezathine with an attendant marked reduction in

* See "The Effects of Ultraviolet Radiation on the Exposed Brain. Experimental Study," by Guy L. Odom, Henry M. Dratz and F. V. Kristoff, to be published in the July ANNALS OF SURGERY.

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infection rate. He states that the six infections recognized during this period were severe and might have been fatal without vigorous antibiotic therapy.

A subsidiary but important by-product of this effort in the reduction of postoperative infection was the finding that the brain may be susceptible to infection by organisms normally regarded as saprophytes or contaminants.[5]

A second as yet unpublished summary of the incidence of postoperative neurosurgical infection has been made available to us through the generous co-operation of Dr. Wilder Penfield, Director of the Montreal Neurological Institute.[6] Every possible effort has been made in that clinic to control the many factors perhaps responsible for postoperative infection. Doctor Penfield's results are particularly significant since they illustrate a reduction in infection rate through the adjuvant use of a modified form of ultraviolet radiation. A definition of the character of these infections is not available. The yearly infection rates are given by Doctor Penfield as follows:

Year	Cases	Number of Infections
1942–43	695	4
1943–44	760	10
1944–45	858	11
1945–46*	968	4
1946–47	871	2
1947–48	914	4

* Installation of modified form of ultraviolet radiation.

The recognition by Cairns and Penfield of the existence and danger of postoperative infection among neurosurgical cases has in each instance resulted in the steady reduction of the infection rate, by different methods, to a relatively negligible factor. If further evidence is required to substantiate the fact that the problem of neurosurgical infection is a real one, and often unanswered, it may be obtained by reading the neurosurgical literature of the time period covered by our report. In four American surgical and neurosurgical journals in the time period January 1, 1938, through January 1, 1948, 2,710 clean neurosurgical cases are reported, among whom 20 patients died as a sequel of postoperative infection.

The statistical data of our survey, with a brief discussion of the findings, are as follows

TABLE I.—*General Summary*

Total clean operative procedures			3,019
Total infections			42
Severe	12	.4%	
Mild	25		
Stitch abscess	5		
Deaths attributable to infection			1
Infection percentage rate			1.39

TABLE II.—*Infections per Year*

	Number of Procedures	Infections	Deaths
1938	170	0	0
1939	202	2	0
1940	275	3	0
1941	190	4	1
1942	232	0	0
1943	210	2	0
1944	252	4	0
1945	321	5	0
1946	425	11	0
1947	477	9	0
1948 (6 months)	265	2	0
Totals	3,019	42	1

TABLE III.—*Infections in Specific Operative Procedures*

	Number of Cases	Number of Infections		Deaths
Craniotomy	1,228	13	1.05%	1
Removal of ruptured disk	1,063	19	1.77%	0
Laminectomy	271	6	2.21%	0
Other*	457	4	.90%	0

* Includes procedures such as lobotomy, trephine removal of extradural or subdural hematomas, resection of meningoceles, peripheral nerve operations, sympathectomies, scalenotomies, ligation of internal carotid artery in the neck, and the like.

TABLE IV.—*Predominating or Single Infecting Organism*

Hemolytic *Staphylococcus aureus*	14
Nonhemolytic *Staphylococcus aureus*	10
Nonhemolytic *Staphylococcus albus*	5
Culture negative	13

DISCUSSION

The duration of hospitalization or the duration of secondary wound healing, the intensity and length of elevated temperature rates, the threat to life or bodily function and the necessity for intensive antibiotic therapy were factors by which the severity of any one infection in this series was measured. Twelve infections were considered to be severe, 25 mild and five were noted as simple stitch abscesses. The incidence of infection was higher in lumbar laminectomies than in craniotomies or upper spine laminectomies. The rate of the severe infections was approximately .4 per cent.

In seeking a cause for individual infection, other than the acknowledged one of air contamination, it is interesting that 27 of the infections were related, if not directly attributable to defects in neurosurgical technique or errors in neurosurgical management. Thus, 12 infections followed the early appearance of operative hematomas, either with or without wound disruption,

five were subsequent to scalp flap necrosis, two appeared when craniotomies were drained through an adjacent stab-wound, two were related to the retention of foreign bodies (triangular fluffs), two occurred in disc procedures in patients who harbored a single cutaneous furuncle, one in a patient with a mild generalized dermatitis, one followed repeated ventricular taps, one occurred in a craniotomy wound that had been packed to control hemorrhage, and one was noted ten days after a tantalum cranioplasty of exceptional magnitude. If these infections were related to extraneous factors, the number presumably due to contamination by air-borne bacteria is significantly reduced.

Among the infections in which a positive culture was obtained, the organism represented some type of staphylococcus, a finding that has been previously demonstrated by Doctor Hart. No seasonal variation was noted in the relatively few infections. The average hospital stay for the patients with any form of infection, severe or mild, was 29.4 days as compared to the average stay for all patients in the year 1947 of 12.7 days. These patients were operated upon by two staff neurosurgeons and the resident neurosurgeons present during the ten-year period of the study.

Summary of case fatality attributed to infection:

Duke Hospital History A-52261, colored male, age 17, was admitted in a stuporous condition to the Neurological Division of the Medical Service on December 3, 1940. Generalized headache had developed 4 weeks prior to admission and the patient had become comatose 4 days before admission. Neurological examination showed, in brief, bilateral papilledema, right hemiparesis and hyperreflexia of the right-sided muscle-tendon reflexes. A provisional diagnosis of tuberculous meningitis was entertained and lumbar puncture demonstrated 100 mononuclear cells, a positive Pandy reaction and increased subarachnoid pressure. All other studies were essentially normal. A left frontal craniotomy was subsequently performed (B. W.) and the left frontal lobe was resected. The resection plane passed through a necrotic neoplasm situated in the base and lateral border of the anterior horn of the ventricle and extending caudally in the temporal lobe. On the seventh postoperative day, in spite of repeated ventricular drainage to reduce pressure, the medial limb of the craniotomy incision ruptured. Later culture from the persistent cerebrospinal fistula showed the presence of non-hemolytic staphylococcus aureus. Death occurred 22 days after operation and autopsy revealed a purulent leptomeningitis. The tumor, disclosed at operation, invaded the left fronto-temporal region, crossed through the corpus callosum and infiltrated the right frontal lobe. The pathologic diagnosis was glioblastoma multiforme.

SUMMARY

Ultraviolet radiation has been used as an adjunct in the prevention of neurosurgical infection during the time period between January, 1938, and July, 1948. Clinical experience with 3,019 clean neurosurgical cases has demonstrated subsequent wound infection in 42 of these cases, an incidence of 1.39 per cent. Twelve of these infections were severe, 25 were considered mild

and five were recorded as simple stitch abscesses. Staphylococcus aureus and albus were the predominating infecting organisms. A considerable number of wound infections appeared to be related, not only to the factor of bacterial contamination from the air, but also to errors in neurosurgical technique and management. In our opinion, this clinical study over a ten-year period indicates that ultraviolet radiation should be considered an important adjunct of the neurosurgeon's armamentarium.

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4 Pennybacker, J. B., M. Taylor and H. Cairns: Penicillin in the Prevention of Infection During Operations on the Brain and Spinal Cord. The Lancet *II*, 159, (Aug.) 1947.

5 Cowan, S. T.: Unusual Infections Following Cerebral Operations. The Lancet *II*, (Nov. 5) 1938.

6 Penfield, W. (Personal communication).

DISCUSSION.—DR. DERYL HART, Durham, N. C.: I believe Doctor Woodhall has leaned backward in including every possible infection in his cases, and in ascribing the one death to an operating room infection; that is, an infection originating during the operation. This man disrupted his wound ten days after operation and died 22 days following operation, at which time there was infection in the wound after it had been draining for 12 days.

In the publications I have made on unexplained infections in operative wounds, we eliminated all the cases where there was an evident cause of infection, such as operation