EFFICACY OF ULTRAVIOLET BLOOD IRRADIATION THERAPY IN THE CONTROL OF STAPHYLOCOCCEMIAS*

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The use of ultraviolet blood irradiation therapy as a safe and efficient control of acute pyogenic infections has been described by several workers in this field, notably Knott and Hancock,¹,² Miley,³‒⁸ Rebbeck,⁹‒¹₂ and Barrett.¹³,¹⁴ Our findings have been in close agreement with the other workers, and have been reported as such with one exception, namely, the value of ultraviolet blood irradiation therapy in the treatment of staphylococccemias, in which we originally reported the failure of ultraviolet blood irradiation therapy to control the progress of staphylococccemia in seven consecutive cases. Recently, we have observed complete recovery from staphylococccemia in nine consecutive cases, and therefore wish to retract our original statement that we believed staphylococccemias did not respond well to ultraviolet blood irradiation therapy.

As the result of our original experience with seven consecutive failures, followed by nine consecutive recoveries of staphylococccemia, following ultraviolet blood irradiation therapy, we naturally wished to find some reason for the marked difference in results, and in carefully going over the records of all sixteen individuals we found that in six out of seven cases of the original failure group, intensive sulfa drug therapy had been given before and/or after ultraviolet blood irradiation therapy was administered, whereas eight of the nine individuals in the recovery group had had no sulfa drugs whatsoever, that the ninth received a small amount of sulfathiazole only, and that before the development of a positive blood culture. This finding is what might be expected after reading the report of Hancock,² whose eight patients suffering from septicemia received no sulfa drug therapy but recovered with ultraviolet blood irradiation therapy alone; similarly a double septicemia, reported by Rebbeck,¹¹ recovered following the use of ultraviolet blood irradiation therapy alone.

TECHNIC

The technic of irradiating blood used by us in this work was originally devised by Knott, and has been described in detail elsewhere.

The clinical application of ultraviolet blood irradiation therapy consists of withdrawing a predetermined amount of venous blood from an individual, titrating it and immediately returning it to the same individual through a Knott hemo-irradiator, a precision machine which automatically exposes the patient's citrated blood to ultraviolet energy safely and efficiently, and returns it immediately to the vein from which it was withdrawn.

A detailed report of results observed following the use of this method in sixteen cases of staphylococccemia follows:

RESULTS IN STAPHYLOCOCCEMIAS

We have divided our results in staphylococccemias into two separate groups: the first consisting of seven consecutive failures of ultraviolet blood irradiation therapy to control the diseased process, six of whom received intensive sulfa drug therapy prior to irradiation, and the second consisting of nine cases of staphylococccemia, all of whom recovered following ultraviolet blood irradiation therapy alone.

* From the Blood Irradiation Clinic, Hahnemann Medical College and Hospital, Philadelphia.
### TABLE I

<table>
<thead>
<tr>
<th>No.</th>
<th>Hospital No.</th>
<th>Type of Staphylococcemia</th>
<th>Primary Infection</th>
<th>Type of Sulfonamide Drugs Used</th>
<th>Number of Blood Irradiations (Total)</th>
<th>Number of Hospitalization Days (Total)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>52117</td>
<td>Aureus</td>
<td>Staph. pneumonia, lung abscess</td>
<td>S* SP</td>
<td>2</td>
<td>7</td>
<td>D.†</td>
</tr>
<tr>
<td>2</td>
<td>Framingham Hosp. 65326</td>
<td>Aureus and albus</td>
<td>Puncture wound of eye</td>
<td>SP S</td>
<td>2</td>
<td>45</td>
<td>D.</td>
</tr>
<tr>
<td>3</td>
<td>64501</td>
<td>Aureus</td>
<td>Prostatic resection area infection</td>
<td>ST S</td>
<td>4</td>
<td>15</td>
<td>D.</td>
</tr>
<tr>
<td>4</td>
<td>48830</td>
<td>Aureus</td>
<td>Wound infection, sinus thrombosis following frontal sinus-ectomoy</td>
<td>ST SP</td>
<td>1</td>
<td>37</td>
<td>D.</td>
</tr>
<tr>
<td>5</td>
<td>60720</td>
<td>Aureus</td>
<td>Wound infection following operation for ingrown toenail</td>
<td>ST SP</td>
<td>2</td>
<td>13</td>
<td>D.</td>
</tr>
<tr>
<td>7</td>
<td>38082</td>
<td>Aureus</td>
<td>Bladder carcinoma, bilateral pyonephrosis, empyema, atelectasis, bronchial pneumonia</td>
<td>NP ST</td>
<td>4</td>
<td>47</td>
<td>D.</td>
</tr>
</tbody>
</table>

* Key:
  - S—Sulfanilamide
  - SP—Sulfapyridine
  - ST—Sulfathiazole
  - NP—Neoprontosil
  - Died

### TABLE II

<table>
<thead>
<tr>
<th>No.</th>
<th>Hospital No.</th>
<th>Type of Staphylococcemia</th>
<th>Primary Infection</th>
<th>Type of Sulfonamide Drugs Used</th>
<th>Number of Blood Irradiations (Total)</th>
<th>Number of Hospitalization Days (Total)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>81994</td>
<td>Aureus</td>
<td>Marked erysiploid inflammatory process of right ear</td>
<td>ST (before appearance of staphylococcemia)</td>
<td>1</td>
<td>20</td>
<td>R.*</td>
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<tr>
<td>2</td>
<td>84630</td>
<td>Aureus</td>
<td>Incomplete septic abortion</td>
<td>None</td>
<td>1</td>
<td>16</td>
<td>R.</td>
</tr>
<tr>
<td>3</td>
<td>88168</td>
<td>Aureus</td>
<td>Incomplete septic abortion</td>
<td>None</td>
<td>2</td>
<td>19</td>
<td>R.</td>
</tr>
<tr>
<td>4</td>
<td>88167</td>
<td>Aureus</td>
<td>Incomplete septic abortion</td>
<td>None</td>
<td>1</td>
<td>10</td>
<td>R.</td>
</tr>
<tr>
<td>5</td>
<td>82484</td>
<td>Aureus</td>
<td>Incomplete septic abortion</td>
<td>None</td>
<td>1</td>
<td>20</td>
<td>R.</td>
</tr>
<tr>
<td>6</td>
<td>83141</td>
<td>Albus</td>
<td>Acute ulcerative rhinitis, acute suppurative otitis media, acute mastoiditis, incomplete septic abortion</td>
<td>None</td>
<td>2</td>
<td>39</td>
<td>R.</td>
</tr>
<tr>
<td>7</td>
<td>82702</td>
<td>Albus</td>
<td>Incomplete septic abortion, purulent endometritis, parametritis, pelvic peritonitis</td>
<td>None</td>
<td>2</td>
<td>12</td>
<td>R.</td>
</tr>
<tr>
<td>8</td>
<td>86768</td>
<td>Aureus</td>
<td>Post-measles upper respiratory infection</td>
<td>None</td>
<td>2</td>
<td>19</td>
<td>R.</td>
</tr>
<tr>
<td>9</td>
<td>50698</td>
<td>Albus</td>
<td>Postcesarean pelvic thrombophlebitis</td>
<td>None</td>
<td>1</td>
<td>33</td>
<td>R.</td>
</tr>
</tbody>
</table>

* Recovered
Group I—Seven Staphylococcemias Not Controlled by Ultraviolet Blood Irradiation Therapy. In this group six individuals receiving ultraviolet blood irradiation therapy alone, six were due to Staphylococcus aureus and three to Staphylococcus albus.

In Table I is shown the protocol of Group One tabulating the salient features observed to occur clinically in this group.

Peak temperature graphs illustrating the absence of beneficial effects in staphylococcemias of ultraviolet blood irradiation therapy used after intensive sulfa drug therapy failed are shown in Figures 1, 2, and 3.

Group II—Staphylococcemias Controlled by Ultraviolet Blood Irradiation Therapy. In this group of nine staphylococcemias received ultraviolet blood irradiation therapy following intensive sulfa drug therapy, five due to Staphylococcus aureus, and one to both Staphylococcus aureus and albus; the seventh, with Staphylococcus aureus septicemia secondary to bladder carcinoma complicated by right-sided atelectasis and empyema, received only ultraviolet blood irradiation therapy. In all seven there was a complete failure to control the staphylococcemia and all these patients died.

In Table II is shown the protocol of Group Two tabulating the salient features observed to occur clinically in this group.

Peak temperature graphs showing the relation of ultraviolet blood irradiation therapy to the subsidence of fever, coincident with generalized detoxification, in three of the individuals from Group Two are shown in Figures 4, 5, and 6.

CASE REPORTS

Six case history abstracts from Group Two are presented:

Case 1. No. 81994. The patient was admitted November 16, 1942, complaining of severe pain and swelling in the region of her right ear. Physical examination revealed a marked edematous erysipeloid inflammatory process around the right ear, and some injection of the right ear drum. Her temperature was 100.0°F., pulse rate 120, and respiratory
rate 24 at this time. Routine hematological examination and urinalysis were negative. Sulfathiazole was started, and given intensively was confirmed by physical examination. Two days later the patient passed two large blood clots. The patient's temperature, which had for three days, during which time the patient's temperature rose to 103.0°F., her pulse rate to 124, and respiratory rate to 28, but finally fell to normal on November 19, 1942. The patient's erysipeloid lesion had improved, there was less injection of the ear drum, so sulfathiazole was discontinued. The patient ran an uneventful course for another three days, but on November 23rd her temperature began to rise again; this rise continued for forty-eight hours to 102.0°F.; the pulse rate rose to 110, at which time the patient suddenly became somewhat toxic. A blood culture taken at this time later proved to contain a luxuriant growth of Staphylococcus aureus. Ultraviolet blood irradiation therapy was instituted immediately after blood culture was taken. Forty-eight hours later the patient's temperature and pulse rate both fell to normal. Blood culture taken November 28, 1942, three days after blood irradiation, was sterile. The patient convalesced uneventfully, leaving the hospital on December 6, 1942, twelve days after a single blood irradiation.

CASE II. No. 84630. This patient was admitted March 10, 1943 to, the septic ward with a diagnosis of incomplete septic abortion which varied from 98.0° to 99.8°F., fell to normal, and the patient was allowed out of bed. Forty-eight hours after being allowed out of bed the patient's temperature began to rise reaching 101.6°F.; her pulse rate rose to 112. The following day, March 15th, the patient became extremely toxic; her temperature rose again, this time to 103.6°F. Blood culture was taken and ultraviolet blood irradiation therapy administered. The blood culture, taken in tryptose phosphate broth, later proved to be positive with a profuse growth of pure culture Staphylococcus albus. On the first post-irradiation day, March 16th, the patient's temperature fell to normal and her toxic symptoms had almost completely disappeared. Forty-eight hours after blood irradiation the patient passed a large amount of secundines, and two days later dilatation and curettage was performed. The patient's subsequent convalescence was uneventful, blood cultures being negative thereafter, and the patient left the hospital March 26, 1942, eleven days after a single blood irradiation.

CASE III. No. 88168. The patient was admitted April 14, 1943, complaining of abdominal pain and vaginal bleeding. Physical

hematological examination and urinalysis were negative; however, on the day following admission the patient's temperature rose to 102.0°F., her pulse rate to 104, her respiratory rate remaining normal; clinically, the patient appeared to be moderately toxic. Ultraviolet blood irradiation therapy was instituted at this time, April 15th, and a blood culture was taken in tryptose phosphate broth; this later proved to be pure culture positive for Staphylococcus aureus, with a rich golden pigmentation apparent in a subculture made on Loeffler's medium. On the following day the patient's temperature rose to 104.6°F., and she appeared more toxic than ever. Forty-eight hours after the initial ultraviolet blood irradiation the patient's condition had shown no improvement but had continued to deteriorate, and her temperature was 103.2°F. at 8 a.m., April 17th. At 9 a.m. a second blood culture was taken which was also pure culture positive for Staphylococcus aureus, which showed much less golden pigmentation in a subculture on Loeffler's medium than did the first culture. As soon as the culture was taken ultraviolet blood irradiation therapy was repeated, and within twenty-four hours following this second blood irradiation her temperature and pulse rate returned to normal; the patient's toxic symptoms had almost completely disappeared. On the second post-irradiation day, April 19th, 250 cc. of whole blood was given. On April 20th, a piece of placental tissue was passed. A blood culture taken on April 24th was negative. On April 27th, dilatation and curettage was performed, followed by no temperature rise whatsoever. The patient continued to convalesce uneventfully, and left the hospital on May 3, 1943, in apparently excellent condition, eighteen days after her original blood irradiation. At no time during this sixteen-day convalescent period did the patient's temperature rise above 98.6°F.

Case IV. No. 88167. This patient was admitted October 30, 1942, to the septic ward, complaining of vaginal bleeding and crampy abdominal pains of two days' duration. Physical examination revealed a bilateral parametrial tenderness, and an enlarged edematous cervix; a diagnosis of incomplete septic abortion was made. During the first twenty-four hours of hospitalization the patient had two very severe chills, her temperature ranged between 99.2° and 100.2°F., her pulse rate between 108 and 140, and her respirations between 22 and 28; the patient was extremely toxic at this time. Urinalysis was negative; erythrocyte count 3,260,000, hemoglobin 11.1 Gm., leukocyte count 14,600 with 85 per cent polymorphonuclears and 15 per cent lym-
phocytes. On the day following admission ultraviolet blood irradiation therapy was given; a blood culture taken just before the blood

irradiation later proved to be positive for Staphylococcus aureus hemolyticus. Her condition improved markedly in the first forty-eight hours following blood irradiation, as evidenced by a marked alleviation of all toxic symptoms; the erythrocyte count was now 3,470,000, hemoglobin 12.6 Gm., and leukocyte count 6,800 with 72 per cent polymorphonuclears and 28 per cent lymphocytes. Dilatation and curettage was performed at this time, November 2, 1942, obviously without knowledge that the blood culture would prove to be positive for Staphylococcus aureus. The patient’s symptoms disappeared entirely following dilatation and curettage, she convalesced uneventfully, and left the hospital November 9, 1942, in apparently excellent condition, nine days after a single blood irradiation and seven days after dilatation and curettage.

Case V. No. 82484. The patient was admitted to the septic ward December 23, 1942, with the diagnosis of incomplete septic abortion complicated by severe hemorrhage. Laboratory examination revealed an erythrocyte count of 2,270,000 and a hemoglobin reading of 9 Gm.; sedimentation rate was suffered a mild transfusion chill, but at the end of forty-eight hours seemed definitely improved. Despite the transfusion, however, the patient’s blood picture remained relatively unchanged, the erythrocyte count varying between 2,080,000 and 2,200,000, and the hemoglobin between 9.4 and 8.3 Gm. The patient’s temperature rose daily to 99.2°F. This more or less static condition prevailed, but the sedimentation rate began to rise reaching 22 mm. and 34 mm. at 15 minutes and 45 minutes, respectively on January 2, 1943. In view of this it was believed that dilatation and curettage was necessary. Preoperative ultraviolet blood irradiation therapy was given January 5th; blood culture taken at this time later proved to be positive for Staphylococcus aureus hemolyticus. Dilatation and curettage was performed on the day following blood irradiation, January 6th, at which time no knowledge of the positive blood culture had been obtained. The patient convalesced uneventfully from this point on, and left the hospital January 12, 1943, in apparently excellent condition, seven days after blood irradiation and six days after dilatation and curettage done within twenty-four hours.
of the time that a positive blood culture had been present.

It is my opinion that this again illustrates the powerful protective effect that had continued to deteriorate slowly, and on January 23rd obstetrical consultation revealed the imminence of a threatened abortion. On January 26th, drainage from the ear had entirely stopped, and the mastoid process had

one can expect from ultraviolet blood irradiation therapy, since one would expect a patient receiving uterine curetage, while bacteria were still present in the blood stream, to undergo a relatively stormy course, and not to be discharged in good condition within a week’s time as was this fortunate patient.

**Case VI. No. 83141.** This patient was admitted to Hahnemann Hospital January 15, 1943, complaining of severe nose bleed and persistent fever. Physical examination revealed an acute ulcerative rhinitis, and an acute suppurative otitis media, associated with a pregnancy of two months’ duration; temperature was 100.2°F., pulse rate 128, respiratory rate 24. Laboratory findings were essentially negative. Her nasal hemorrhage was easily controlled by nasal packing, but the acute otitis media increased in severity in the amount of copious purulent discharge. On January 19th, the patient began to complain of a throbbing sensation in the affected ear. Although her temperature had dropped to a level of 99.0°F., the patient’s general condition became extremely tender. Ultraviolet blood irradiation therapy was instituted, and blood culture taken at this time proved to be positive for Staphylococcus aureus in pure culture. Subsequent cultures were negative. The patient convalesced uneventfully.
patient convalesced uneventfully, her temperature slowly falling to normal, and she left the hospital in apparently excellent condition February 23, 1943.

![Graph showing temperature and blood tests](image)

Fig. 6. (Group 2.) Case viii. This patient, a student nurse, was given ultraviolet blood irradiation therapy initially to control what we believed to be an acute influenzal pneumonitis following measles. It was not until after a second blood irradiation was given that blood culture taken on admission proved positive for Staphylococcus aureus, as did a second blood culture taken just before the second blood irradiation. Forty-eight hours after the second blood irradiation the patient’s toxic symptoms began to subside, blood cultures became sterile, and her temperature dropped to normal with subsequent uneventful recovery.

**CLINICAL OBSERVATIONS**

The recovery of nine individuals with staphylococcemia receiving ultraviolet blood irradiation therapy alone was certainly the opposite from the results observed in the seven individuals who also were suffering from staphylococcemia but who died despite ultraviolet blood irradiation therapy given after or along with intensive sulfa drug therapy. The chief difference between the two groups receiving ultraviolet blood irradiation therapy is obviously the use of the sulfa drugs in the group that died.

In the recovery group there occurred the same sequence of events already reported to occur in other acute pyogenic infections.2,3,7,11 These are briefly (1) a marked detoxification effect manifested by a pronounced subsidence of toxic symp-

toms, such as nausea, vomiting, delirium, fever, general malaise, high pulse and respiratory rates, and mental confusion; (2) a complete disappearance of the invading bacterial organism; (3) grossly discernible peripheral vasodilation, and (4) a complete absence of deleterious effects.

Apparently the use of sulfa drugs so greatly lowered the resistance of the individuals in Group One that ultraviolet blood irradiation therapy was no longer able to be of any benefit to these patients. This may possibly be due to the fact that once sulfa drugs fail to control an infection one encounters all the ill effects of a toxic drug, producing generalized tissue anoxia, superimposed upon the toxic products of bacterial growth and decomposition. In any event, it is our opinion that the use of the sulfa drugs in the cases of staphylococcemias seen by us has had no beneficial effect whatsoever, but on the contrary has so seriously lowered the individual
patient’s resistance that recovery was made impossible, even after receiving ultraviolet blood irradiation therapy, a therapy which in Group Two has been found to yield encouraging results in staphylococcemias not complicated by the use of sulfa drugs, which are rather generally known to have little or no effects on most staphylococcemias.

SUMMARY

There has been presented a report and analysis of sixteen cases of staphylococcemia given ultraviolet blood irradiation therapy as a method of controlling this type of acute pyogenic infection.

The first seven staphylococcemic individuals treated by ultraviolet blood irradiation therapy failed to respond and died. Six of these seven received intensive sulfa drug therapy, whereas the seventh, whose staphylococcemia arose from a bladder carcinoma and was complicated by atelectasis and empyema at the time of institution of ultraviolet blood irradiation therapy, received only blood irradiation and also died.

The results of ultraviolet blood irradiation therapy in a second group of nine consecutive staphylococcemic individuals given blood irradiation was reported; all nine of these individuals recovered uneventfully; eight of the nine received no sulfa drugs whatsoever, and the ninth, forty-eight hours of sulfathiazole therapy one week before blood culture became positive.

In each of the sixteen cases reported one or more pure cultures of pathogenic strains of either Staphylococcus aureus or Staphylococcus albus were obtained from blood cultures taken in tryptose phosphate broth.

In fifteen of the sixteen cases there was present a profound toxemia at the time of institution of ultraviolet blood irradiation therapy.

Uterine dilatation and curettage was performed in three individuals of Group Two, the recovery group, while the blood culture in each of the three individuals was still positive. No untoward effects were observed to follow this radical procedure performed despite the presence of staphylococci in the blood stream.

CONCLUSION

1. The apparently paradoxical recovery following ultraviolet blood irradiation therapy in nine consecutive cases of staphylococcemia, after its original reported failure to control acute pyogenic infection in the first seven cases of staphylococcemia we treated, can be attributed to the fact that sulfa drugs were used intensively in six of the seven failures, and that ultraviolet blood irradiation therapy alone was used in the nine individuals recovering from staphylococcemia following ultraviolet blood irradiation therapy.

2. It is our opinion that sulfa drugs are contraindicated in most cases of staphylococcemia.

3. Ultraviolet blood irradiation therapy alone has proved to be a successful method of controlling the acute pyogenic infection in nine consecutive cases of staphylococcemia.

4. The earlier ultraviolet blood irradiation therapy is applied in any acute pyogenic infection, including staphylococcemias, the better are the chances of recovery.

5. The use of sulfa drugs in six cases of staphylococcemia appeared to lower the resistance of each of these patients so severely that the use of ultraviolet blood irradiation therapy, successful when used alone in nine consecutive cases of staphylococcemia, was no longer able to control the staphylococcemia.

6. We must retract our original statement that ultraviolet blood irradiation therapy has little or no effect upon staphylococcemias, and admit that, when used alone, this procedure has been successful in controlling staphylococcemia, at least in nine consecutive cases.
Finally, the use of ultraviolet blood irradiation therapy is preferable to the use of sulfa drugs in the treatment of staphylococcemias.

REFERENCES