illness. It would appear, however, that the normal immunity response of the body failed to reinforce passive immunization, since circulating antibodies were not found in a particular case tested on the seventh day of illness. These patients collapsed and died from the shock of the disease or from meningitis; their vital response was, in fact, overwhelmed at an early stage by the severity of the infection. Similarly, in a rabbit to which an excessive dose of killed pneumococcal vaccine was given experimentally, response was delayed ten days from the third, the normal day of appearance of immunity, till the thirteenth day after inoculation.⁷ Further experience is required in the application of serum treatment to severest cases of pneumonia.

GENERAL METHODS OF TREATMENT

It is important to realize that treatment by concentrated anti-pneumococcal serum does not replace general measures, of which the most essential are: (1) a minimum of disturbance of the patient, (2) early digitalization to conserve cardiac energy, (3) sedatives to procure sleep, (4) glucose, with alcohol as required, to furnish a readily assimilable food, and (5) oxygen—less often necessary in the treated than in the untreated case owing to the favourable effect of serum on the cyanosis and toxæmia.

SUMMARY

1. Serological type of the responsible pneumococcus in lobar pneumonia can be decided in a few minutes, early in the illness, by simple direct test on the patient's sputum. No special apparatus or skill is required; animal inoculation is abolished.

2. Approximately two-thirds of cases of lobar pneumonia in winter are due to infection by pneumococcal Types I and II, and are therefore suitable for serum treatment.

3. At the beginning of treatment an initial desensitizing dose of 1 c.cm. of serum should be injected intravenously, to be followed, twenty to thirty minutes later, by the main inoculum.

4. Serum treatment shortens the duration of fever and favours termination by crisis, particularly in Type I infections.

5. There is marked symptomatic improvement following serum treatment. The earlier serum is administered the more frequently is the illness aborted, the favourable effects observed being inversely proportional to the time elapsed from onset of illness till serum treatment.

6. Serum treatment appears to restrict the spread of pneumonia from one side of the chest to the other, particularly in Type I infections.

7. Complications and sequelæ are apparently uninfluenced by serum treatment.

8. The results of serum treatment in the severest type of case have been, on the whole, unsatisfactory. Further research is needed in this direction.

ACKNOWLEDGEMENTS

The observation and treatment of cases has been carried on at St. Bartholomew's and the following London County Council Hospitals: Hackney Hospital, St. Olave's, St. Andrew's, Mile End Hospital, St. Peter's, and Bethnal Green Hospital; a few cases were studied at the Victoria Park Hospital. Thanks are due to the staffs of these institutions for unremitting encouragement and help. The serum used in the London County Council hospitals was provided by the Council, and particular acknowledgement is made to the Medical Officer for this provision and for permission to work in the several hospitals named. The Medical Research Council provided the serum used at St. Bartholomew's, and defrayed the general expenses of the inquiry, to which the Cattlin Fund contributed an important share.

REFERENCES

- ¹ Armstrong and Johnson: *British Medical Journal*, 1931, i, 931.
- ² Armstrong: *Ibid.*, 1932, i, 187.
- ³ Neufeld, F.: *Zeit. f. Hyg. u. Infektionsk.*, 1902, xl, 54.
- ⁴ Stryker, L. M.: *Journ. Exper. Med.*, 1916, xxiv, 49.
- ⁵ Sutliff and Finland: *Journ. Amer. Med. Assoc.*, 1931, xcvi, 1465.
- ⁶ Armstrong and Johnson: *Med. Supp., Rep. Hosp. Services*, London County Council, 1932, iv, Part 3.
- ⁷ Armstrong: *Proc. Roy. Soc., B.*, 1925, xcvi, 539.

TREATMENT OF INFLAMMATORY CONDITIONS BY RADIATIONS *

BY

J. H. DOUGLAS WEBSTER, M.D., F.R.C.P.ED.
(From the Radiological Department, Middlesex Hospital)

ACUTE INFLAMMATORY DISEASE

The acute inflammatory affections range in severity from the most trivial furunculosis to pyæmic states complicating osteomyelitis, endocarditis, or other severe infection. Many isolated reports in the early literature suggested that radiotherapy might be of assistance in combating the progress of local sepsis resistant to the usual surgical measures, but it was the work of a surgeon, Heidenhain, and his assistant Fried, in Worms, which instituted a systematic clinical research into this field, and the publication of their nine years' results in 1924, on 243 cases, has aroused much interest in this little-known sphere of radiotherapy. Holzkecht has said, from several hundred cases of his own, that "we have to do with a great roentgenotherapeutic advance in the x-ray treatment of the coccal inflammations."

X-ray treatment has been found most useful when given in 15 to 20 per cent. doses (surface doses) in furunculosis, carbuncle, whitlow, erysipelas, and a considerable number of deeper-lying inflammatory states.

* Read in opening a discussion in the Section of Radiology at the Centenary Meeting of the British Medical Association, London, 1932.

The results are best when no previous surgical treatment has been given: should fluctuation appear, a simple aspiration or stab-incision drainage should be carried out. Sterile pus has frequently been found, and some experiments show that in addition the pus may have a high bactericidal power. Seeman, in 171 cases, had very similar results to those of Heidenhain and Fried: thus in axillary sweat-gland abscess he had, out of twenty-seven cases, 91 per cent. good results. Of the deeper infections, he treated six chronic appendix abscess cases, two-thirds of which responded well; while two kidney abscess patients, with renal pain and swinging temperatures, who were passing blood and pus, showed a prompt improvement—loss of pain in a few hours, and rapid subsidence of all infective signs—following a single radiation. Seven acute mastitis cases and fourteen patients with pneumonia were treated: to the first he gave 40 per cent. doses with 100 per cent. good results; to the pneumonia cases he began with 5 to 10 per cent. doses, and in just over half the patients there was rapid lysis and resolution. Holfelder reports rapid response in post-operative hypostatic pneumonia and in acute gonococcal arthritis: he warns against roentgenotherapy in acute infections where the process cannot be easily observed clinically. Thus it is not suitable treatment for acute osteomyelitis, acute abdominal infections, or acute otitis media.

It is evident that further study of these acute coccal inflammations is desirable, as much of this region is still largely unexplored.

MODE OF ACTION OF RADIATION

There are many interesting problems for discussion in the observed and possible modes of action of radiations in coccal and other infections. Many experiments appear to show that x rays and radium rays have no direct destructive power on micro-organisms, but recent research at the Rockefeller Institute (Wyckoff and Rivers) has shown that cathode rays directed on to thin, unclumped smears have a powerfully destructive action. *B. coli*, *B. aertrycke*, and *Staphylococcus aureus*, when they absorb one electron at 155 kV, die. The absorption of an electron liberates such an ionic shower in the cell (10^4 ions in 0.001 mm.³) that it must be severely damaged or die. Thus even a mild penetrating radiation of an inflammatory focus must kill many organisms, and hasten absorption or maturation. This is what has often been observed clinically after x -ray or radium treatment of, for example, infected or tuberculous glands in the neck.

Apart from the action directly on the organisms of infection, there are the effects, somewhat similar to inflammation, in vessel and lymph engorgement, diapedesis, etc., in the part irradiated; damage, in a lesser or greater degree, to the blood and tissue cells, leading to a protein-shock therapy; chemical action on cell ferments; and probably reactive regeneration stimulation, as is shown by the proliferation of fibroblasts. There is much already known, and much that must still be the subject of research, in the action of radiations. But in inflammatory affections the effect of small doses chiefly must be studied: some of the results of Maximow—for example, on experimental inflammation in the abdominal wall of rabbits, showing extreme fibroblastic damage—seem to me to be invalid because too large doses were given. Even extremes of sunlight or ultra-violet light can severely damage the blood, and all light treatment dosage, in inflammatory conditions especially, must be cautious.

CHRONIC INFLAMMATORY DISEASE

Actinomycosis.—Of the specific chronic infections actinomycosis for long has been known to respond—often well—to x -ray or radium treatment. Doses rather larger than those advised in acute inflammations are proved to be the most efficacious—that is, 40 per cent. or more. Actinomycosis in the most diverse sites—appendix, lungs, and other rarer places—has been recorded as having reacted well. Nearly all my patients have been jaw or neck cases: most have continued iodine medication as well as having x rays or radium: the results on the whole have been very satisfactory.

Tuberculous Infection.—Among the earliest chronic inflammations treated by radiation were the tuberculous skin and gland infections. To these in more recent years has been added tuberculosis of practically all the other organs, and by now the literature on this subject is immense. The complete revolution which has passed over the medical world in the treatment, for example, of tuberculous glands and bones, from the time when most of us here present were medical students, is one of the most striking achievements of modern medicine: much of it is due to the pioneers in actinotherapy and radiotherapy. The main treatment is now the general regimen, with some form of radiation therapy, and conservative surgery if indicated. Time does not permit of my dealing with this subject in any detail: I should like to say a word on dosage, however. The tubercle is largely a defence mechanism set up by the tissues as a reaction to the bacillary invasion, and its destruction by radiation is therefore to be deprecated. Overdosage can lead to damage by setting free otherwise immured bacilli, just as excessive tuberculin dosage can cause harm. In tuber-

culous neck glands I have usually given one-sixth of an E.D. at weekly or longer intervals. Cases which cease to respond to local treatment I usually try with a short series of spleen doses, also of a sixth, or a third, of a skin dose. Manoukhine has advocated this spleen radiation in many tuberculous infections, particularly in pulmonary cases; I have treated pulmonary patients with this method, but think that usually a very cautious direct attack is more likely to be effective.

Chronic Sinusitis.—There are a number of reports of successful treatment of nasal sinuses by x rays, auxiliary to surgical drainage. My own experience has been mostly with those general surgical sinuses which are obstinate in healing, such as appendix or ischio-rectal sinuses, or those following operations on glands in the neck. Thus a patient who had had three operations for ischio-rectal abscess had a sinus which refused to heal, and two or three mild deep x -ray applications had a prompt effect. Many of these sinus patients have been seen with Mr. Sampson Handley, who has often taken the opportunity to express satisfaction with the results of x rays in refractory cases, with or without a preliminary injection of bismuth oil or paste.

Skin Disease.—Of the chronic inflammatory skin disorders many show the most striking success from radiation therapeutics. Thus McKee instances the x -ray treatment of acne indurata as outstanding for its rapidity and permanent effect. In acne I have generally found small doses of a sixth of a skin dose, repeated at weekly intervals, to be the best. In the chronic eczemas, such as of the eyelids, ears, lips, scalp, or hands and feet, many patients will be found to respond rapidly to similar or slightly larger doses—doses of one-sixtieth have been used in Vienna clinics. Chronic axillary sweat-gland inflammation may only be cured by amounts sufficient to cause a defluvium: this is also true of sycosis (coccogenic) of the beard region.

Tonsils and Adenoids.—Chronically enlarged and septic tonsils in children are among the most radio-sensitive of all pathological conditions. Children reporting with poor chest development, chronic nasal and throat catarrh, anaemia, loss of appetite, and absence of the natural child's *joie de vivre*, may be entirely changed for the better after a few x -ray treatments, and tonsils which have been almost meeting in the mid-line have shrunk to normal. In adults, where much fibrosis from repeated attacks has not occurred, excellent results may also be obtained. The method I have employed is to treat the patient lying supine, with the head turned well to the side, from behind the angle of the jaw, a small field of $1\frac{1}{2}$ to 2 inches being used. Patients with marked skin sensitiveness I have treated by cross-fire, from below and in front, and above and behind the angle: by this way not the slightest skin reaction will be caused with the usual doses of 2-4 H, and 3 mm. Al filter, repeated fortnightly or at longer intervals. It is needless to say that by this technique there is no possibility whatever of damage to the parotids, thyroid, or parathyroids, as certain critics have asserted. It is one of the most harmless of all medical treatments. Radium may be applied directly, but the retention of such a radium application is very unpleasant for most patients, and impossible for some; further, the radium reaction is often painful. X rays are to be preferred as an agent here, and the results are so good that I believe operation will in time be reserved only for exceptional cases in adults.

OTHER CONDITIONS

Gastric Ulcer.—The x -ray treatment of gastro-duodenal ulcer is based on a number of experimental and clinical findings as to the effect of radiation on the vagotonic

system, the reduction of gastric acidity, and the healing of ulcers as observed radiologically during treatment. Most radiologists have had patients who declared they were much better after a prolonged series of barium meal examinations—a result which is often, I believe, not purely psychological, but due to lessening of spasm and infection tendency, following diagnostic radiation. This is much more often seen after therapeutic x -ray treatment in any part of the gastro-intestinal tract. There is, in addition, a lessening of the gastric acidity. To exclude the possibility of a merely suggestive effect of the radiation, Lenk has on a number of occasions pretended to give an x -ray treatment, but inserted a thick lead filter. On none of these occasions was there the usual response of lessened pain which follows ulcer treatment. Schulze-Berge and Matoni reported on 140 patients, with 77 per cent. clinical cures and 13.5 per cent. improved. The most remarkable improvement from the patient's point of view is the rapid loss of pain. The local tenderness to palpation is then relieved, and appetite and weight improve. Haemorrhage may be lessened by spleen radiation as well. I have had several cases of gastric ulcer; one with a very large ulcer on the lesser curvature, probably malignant, which was treated with larger doses than the usual third or quarter skin dose given in simple ulcer cases: the patient left hospital much improved, but went downhill with general and mental weakness, from which she had suffered for some years; the post-mortem examination showed much colloid material, and little or no sign of malignancy: the ulcer was practically healed. The question of operation after x -ray treatment needs careful consideration in each case. The probable vessel state is important: one patient sent from Dr. Izod Bennett, because of failure to improve under medical treatment, died about two months afterwards from an acute ulcer following a partial gastrectomy. Some post-operative ulcers, gastric or jejunal, have received benefit from x rays. I believe that in gastro-duodenal ulcer there is a valuable sphere opening out for x -ray treatment, to patients not responsive to medical treatment. X rays should, I maintain, be given a few months' trial before surgical treatment is advised in cases showing no urgent surgical indications. The doses are small as compared with cancer treatments, and after pre-operative stomach cancer treatments little or no increased difficulty in the operation or delay in healing has been found.

Gynaecological Inflammatory Disease.—Gonorrhoeal and other forms of salpingitis, parametritis, and pelvic peritonitis, especially tuberculous infections, often respond well to doses beginning with a twelfth of a skin dose or less at the depth. Utin, from Menge's clinic, reports that of twenty-four tuberculous adnexa patients twenty-one were cured; and Sippel, from Bumm's clinic, described seventeen cases with 76 per cent. good results.

Chronic mastitis, whether truly inflammatory or not, as is disputed, usually responds very well, with lessening of pain and shrinkage of the nodules. I have reported an 88 per cent. cure of nearly 100 patients.

Otosclerosis.—The exciting cause of this form of progressive deafness is thought to be inflammatory by J. S. Fraser and some others: Manasse calls it a "chronic metaplastic otitis." I reported two cases treated by x rays about ten years ago, and have now treated about twenty patients, many in collaboration with Mr. E. B. Waggett. We hope to make a detailed report before long, so I shall content myself now with saying that the work of Frey and Kriser, and others of us, who have followed Siebenmann in trying x -ray treatment in this otherwise practically hopeless condition, is, I believe, on the right lines. It can slightly improve in some patients the hearing in early cases, and can arrest the progress of

the disease in many later cases. I saw a patient lately whom I had treated about ten years ago: there was no progress whatever in the impairment of hearing. The new, soft, spongy bone at the foramen ovale is rather similar to the new, soft, osteophytes in arthritis or the exostoses sometimes seen after amputations: x -ray treatment has sometimes arrested the growth of these.

Chronic Arthritis.—Both the newer osteophytes and the soft-part indurations may be affected for good by x -ray treatment, the pain greatly relieved, and range of movement improved. If there is much cartilage destruction in arthritis deformans little improvement in movement can be hoped for in joints such as the hip unless extension be also carried out for a prolonged period to allow of cartilage regeneration.

Keratitis and other Ocular Inflammations.—In the last few years I have had about eighty eye cases, mostly seen in collaboration with Mr. Affleck Greeves, and the results of x -ray treatment in acne rosacea keratitis, and other forms of keratitis, have been almost uniformly excellent. Patients who had had month- or year-long trouble with recurring subacute attacks of corneal irritation and pain have been relieved after one or a very few x -ray applications. The doses given have been a sixth of a pastille dose through 1 mm. Al filter: in recent years these doses have been applied cross-firing the cornea from each side, so as to give the least possible radiation to the lens. Another condition in which good results have been found is iridocyclitis, and a few intractable corneal ulcers have also responded well.

Cancer and Inflammation.—The acute inflammatory type of breast cancer, often mistaken at first for acute mastitis, is non-operable, and the only chance for the patient is the earliest possible radiation treatment. Chronic sepsis complicating cancer is a most important sphere of study, and too little is known about it from both the side of pathology and that of treatment. Before radium treatment or operation on a septic cancer of the cervix, for example, a preliminary x -ray irradiation may be given of a 20 per cent. dose (depth dose); in a few days there may be apparent a lessening of the sepsis, and further treatment may be carried out with more safety and success. Before Wertheim's operation in particular this pre-operative x -ray treatment has by some been found beneficial. Its adoption might also prove useful before tongue, oesophagus, stomach, and rectal operations or radium insertion. I have also practised it before beginning a full course of deep x rays in, for example, a septic ulcerated breast cancer.

BIBLIOGRAPHY

- Fraser, J. S.: *Proc. Roy. Soc. Med., Section of Otolaryngology*, 1915-16, ix, 43; *Journ. Laryngol.*, 1916, xxxi, 465; *Laryngoscope*, 1923, xxxiii, 891.
 Frey, H., and Kriser, A.: *Zeit. f. Hals-, Nasen- u. Ohrenh.*, 1923, vi, 334.
 Greeves, Affleck: *Trans. Ophthal. Soc.*, 1930, 1, 111.
 Heidenhain and Fried: *Langenbeck's Arch.*, 1924 S.; *Zentralbl. f. Chir.*, 1927, No. 19, S. 1184.
 Holfelder, H.: *Lazarus's Handb. d. gesamt. Strahlenth.*, 1931, 2, S. 957; *Handb. d. Roentgenth.*, 1928, 3, 4, S. 628.
 Holzknecht, G.: *Acta Radiol.*, 1926, vi, 607.
 Lenk, R.: *Lehrb. d. Strahlenth.*, 1926, 3, S. 471.
 Manasse, P.: Quoted by Brühl in *Denker und Kahler's Handb.*, 7, S. 409.
 Maximow: *Journ. Exper. Med.*, 1923, xxxvii, 319.
 Schulze-Berge: *Strahlenth.*, 1922-3, xiv, S. 650.
 Seeman, O.: *Beitr. z. Chir.*, 1927, 141, S. 454.
 Sippel and Utin, quoted by Seitz: *Handb. d. gesamt. Strahlenth.*, 1931, 2, S. 391.
 Webster, J. H. D.: *X-ray Treatment of Otosclerosis*, *Arch. Rad. and Elec.*, 1921, xxvi, 69; *Lancet*, 1921, ii, 647; *Chronic Mastitis*, *Lancet*, 1928, ii, 63; *British Medical Journal*, July 9th, 1932, p. 47.
 Wyckoff, R. W. G., and Rivers, T. M.: *The Effect of Cathode Rays on Certain Bacteria*, *Journ. Exper. Med.*, 1930, li, 921.