further 30,000 sanatorium beds, with staff accommodation and the necessary personnel, also 30,000, would be required.

Though hospital building may be delayed there is not the same objection to early recruitment of staff and a serious attempt to add their number to those already employed in home supervision and treatment. The possibilities of this would be affected by varying degrees of urbanization and industrialization, but wherever feasible the personnel and facilities for home treatment of selected cases might be considered by regional hospital boards and local health authorities in conjunction.

Such a change in emphasis on home treatment has had serious consideration for many types of long-term illness in the pioneer work of the Montefiore Hospital, in New York City, which began in January, 1947. A striking feature of this successful project has been its relative economy, the cost per day to the hospital being only 25% of in-patient treatment.

Other interests have been stimulated to plan on similar lines, and the progress of pilot schemes in the cities of New York, Newark, N.J., Richmond, Va., San Francisco, and Montreal deserves close attention, not only with regard to the care of long-term illness in general but because of the lessons they may provide for the home treatment of tuberculosis.

7. An Economic and Social Evolution

Evidence is available of the adverse effect of defective nutrition on the tuberculosis death rate. An upward trend of the tuberculosis mortality figures of certain age groups during recent years has been noted in the industrial north of Great Britain, though the factors operating are not clearly discernible.

Rehousing of families to provide a separate bedroom for the affected member and to avoid overcrowding of the remainder is a common feature of public health authorities' work both at home and abroad.

Economic security, as well as adequate nourishment, is a recognized element in programmes of control; but the amount of assistance and the desirable level of security relative to that of the average wage-earner are not scientifically estimated.

In the home workshops and the sheltered industries of Stockholm, the Altro factory of New York City, and the successful schemes of the United Kingdom there are pointers of which the implications are recognized in the Disabled Persons (Employment) Act, 1944.

Summary

There are certain measures common to programmes for the control of respiratory tuberculosis, of which case-finding facilities and adequate bed accommodation are prominent features in successful schemes.

The other main features of anti-tuberculosis campaigns are described.

The present specific measures for the control of tuberculosis in the United Kingdom are not sufficient to accelerate the natural downward trend of mortality rates.

There are deficiencies in the numbers of hospital beds and staff and also in case-finding facilities.

Respiratory tuberculosis, though it has strong priority claims on institution accommodation and personnel, will receive only a percentage allocation of beds in the foreseeable future.

There is some evidence of the practicability and the economy of home treatment, under certain circumstances, of long-term illness from which respiratory tuberculosis need not be excluded, provided staff and equipment are made available for the purpose.

It is important to assure by adequate measures of rehabilitation that successfully treated cases stay well.

BIBLIOGRAPHY

- Bagley, B. B. (1948). Report to National Tuberculosis Association Annual Meeting, New York.
 Bluestone, E. M. (1948). April Survey, New York.
 Bogen, E. (1949). *Amer. Rev. Tuberc.*, **59**, 707.
 Brink, G. C. (1947). Ontario Department of Health Report of Mass X-Ray Surveys.
 Cherkasky, M. (1948). 1st Annual Report Department of Home Care, Montefiore Hospital, New York.
 — (1949). 2nd Annual Report Department of Home Care, Montefiore Hospital, New York.
 Elliot, W. (1949). *British Medical Journal*, **2**, 297.
 England, N. (1947). Annual Report of Medical Officer of Health for Oxfordshire; Tuberculosis Section.
 Heaf, F. (1947). *Mon. Bull. Min. Hlth*, **6**, 184.
 Myers, J. A. (1948a). *Amer. Rev. Tuberc.*, **57**, 107.
 — (1948b). *Publ. Hlth Rep., Wash.*, **61**, 1563.
 Shepard, W. P. (1948). Report to National Tuberculosis Association Annual Meeting, New York.

CORAL ULCER

BY

FRANK S. PRESTON, M.B., Ch.B.

Surgeon Lieutenant, R.N.V.R.

The seven cases described in this paper occurred among officers and ratings of H.M.S. *Challenger* during a survey of the eastern seaboard of Qatar Peninsula, in the Persian Gulf, during the months of January and February, 1949.

The name "coral ulcer" is given for want of a better one. Little can be found in the literature on the subject, though the condition is well known among the fishermen and pearl divers of the western seaboard of the Persian Gulf and occurs among the fishermen of Ceylon also. Wyville Thomson, in his *Scientific Reports on the "Challenger" Expedition, 1872-1876*, reports the condition briefly, but says little except to advise the wearing of stout boots on coral reefs. Paradise (1924), a member of the 1924 Great Barrier Reef expedition, gives a good description of the condition and discusses treatment. Byrne (1924) reports the condition in Japanese pearl divers and in bêche-de-mer lugger crews working out of Thursday Island, as well as in himself and ratings of the Royal Australian Navy. Levin and Behrman (1941) report a case in the West Indies and discuss treatment with x rays. Bonnevie (1948) describes "Dogger Bank itch," which is caused by a coralline similar in some ways to the tropical corals.

Clinical Features

The patient first complains of lacerations of the feet, legs, or hands after contact with living coral reefs. In some cases the lacerations may pass unnoticed or be so minute as to escape attention, or may even be absent.

Some 12 to 24 hours later he begins to complain of pain in the injured area. This is fairly severe, especially on walking. In a few hours a spreading area of cellulitis appears around the wound. The laceration gapes and discharges a thin grey serous pus. The course is slow and painful, and deep ulcer formation is inevitable. It is accompanied by cellulitis, lymphangitis, enlargement of the local lymphatic glands, and (rarely) fever and malaise. The ulcer is as a rule disabling and the pain quite out of proportion to the physical signs. The patient is often unable to walk for weeks or months after the injury, especially if it is on a weight-bearing area. The course is punctuated by sudden relapses, when the condition flares up again without warning.

The Coral Polyp

To appreciate the aetiology and treatment of the condition an attempt must be made to study the location, life-cycle, and habits of the individuals that make up these large colonies or reefs.

Corals, except in their embryo state, are sessile creatures living in large colonies and feeding on small motile marine organisms which they capture by means of a specially developed mechanism. They live in the warm waters of the world, a sea-water temperature of 60° F. (15.5° C.) being necessary for their survival. The colonies exist usually near the surface, but deep-sea types are known. They secrete a hard calcareous shell around themselves by precipitating calcium from sea-water—an action performed by the individual polyps. The skeletons join up to form the mass of the colony, and eventually a reef is formed which remains many years after the death of its contained polyps.

The polyp has both sexual and asexual methods of reproduction. In the sexual form the union of germ cells results in a free-swimming ciliated planula larva about 1 mm. in length. The planula, though lacking the mouth and enteron of a typical larva, may live on yolk food for periods long enough to bring about considerable dispersion. This is typical of all corals and anemones. Vaughan found in 1919 that the pelagic period of corals was between one day and three weeks. On settling on a hard bottom, the planulae develop mouths and tentacles for feeding, and shortly afterwards the organs for reproduction are formed.

In the asexual form there is simple fission—formation of daughter cells by budding—and the development of a large colony is thus initiated from one individual. The skeletons of these asexually produced individuals form large sponge-like coral heads, some of them extending to as much as three metres in diameter and containing many thousands of polyps. In four years a new colony will reach a diameter of 50 mm.

The feeding mechanism of the polyp is interesting and demands special attention. The adult polyp, being a sessile creature, so to speak “moored” to its skeleton and joined to its sisters in the reef or head, has developed a special feeding mechanism for capturing and digesting its prey. The diet consists largely of small motile marine organisms which abound in their thousands over the reefs.

Like the medusae of the Obelia class, the polyp has specially adapted ectodermal cells called nematocysts containing a coiled thread which ends in a dart-like silica head. This head contains a fluid of considerable physiological effect which has an action not unlike that of cantharides. The whole apparatus is developed in an interstitial cell called a cnidoblast, which, as it reaches maturity, migrates towards the surface of the polyp and at one point is elongated into a delicate process—the cnidocil, or trigger hair. When the cnidocil is broken by a passing organism or body the dart is ejected with considerable force from the cnidoblast into the body of the victim, where the released toxic fluid, rapidly spreading, causes complete paralysis, enabling the polyp to grasp the victim in its tentacles.

Certain types of these animals like the medusae can penetrate normal human skin; this is also seen in the sea-anemones of the genus *Hellenopolypus* and *Actinia*. The Portuguese man-of-war (*Physalia*), too, can penetrate human skin.

In the case of corals, however, the darts are probably shot into the open lacerations sustained concomitantly through contact with the calcareous skeletal mass of the colony. Minute puncture wounds of the feet and legs may pass unnoticed, but where they occur on living coral the

chances of penetration by these minute bodies, or even by small broken-off fragments of coral, are greatly increased. There is therefore a distinct possibility that the contained “physiological fluid” is released in open coral cuts or under the skin. The effect of this fluid in susceptible persons is considerable and may produce shock and collapse, together with considerable local irritation.

Case Reports

Case 1.—A lieutenant aged 26 sustained a puncture wound of his right heel while walking across a reef. When he returned to his ship six days later there was a closed puncture wound 1.2 cm. in diameter over the ball of the right heel covered by a thin scab. The wound was surrounded by an area of cellulitis 5.2 cm. in diameter and there were several tracks of lymphangitis on the lateral aspect of the foot and lower leg. The inguinal glands were not tender or enlarged. The whole area was very tender and acutely painful on walking. There was no evidence of underlying pus. Rest, poulticing, and penicillin (three doses of 200,000 units six-hourly) were prescribed. Twenty-four hours later the wound was excised and a small amount of grey serous pus obtained, which on culture gave pure colonies of *Staphylococcus albus*. Seven days later he suffered a relapse, and a second ulcer broke out on the lateral aspect of the foot. The ulcers were curetted on alternate days with a Volkmann spoon. The primary ulcer now measured 1.5 cm. in diameter and 1 cm. in depth, the muscles of the foot being visible in the base. The ulcer of the lateral aspect was 2 cm. in diameter and 1 cm. in depth; a small piece of coral was obtained from this ulcer. X-ray examination revealed no other foreign bodies of macroscopic size. The condition slowly resolved, but the patient was absent from duty some 51 days in all. Weight-bearing was painful at first, but once the scars were sound he was able to walk on the affected foot.

Case 2.—An able seaman aged 19 got three coral puncture wounds of both ankles around the medial and lateral malleoli while wading ashore. On return aboard 14 days later the two medial wounds of his right leg were covered with thick scabs and seemed to be in an advanced stage of healing. The lateral wound of his right leg was 0.8 cm. in diameter and 0.5 cm. in depth; this was painful on pressure and from it oozed a grey serous pus. There was no evidence of cellulitis. Culture revealed pure colonies of *Staph. albus*. After five days' treatment with magnesium sulphate dressings and elevation of the limb the patient was returned to full duty with the ulcer apparently healed. Four days later he returned from a detached survey with the ulcers of both legs broken down. Complete rest in bed with elevation of the limb was ordered. Full excision of the ulcers was performed and dressings of magnesium sulphate in glycerin solution were applied six-hourly. Between dressings the feet were bathed in eusol. Penicillin, 200,000 units intramuscularly, was given six-hourly. The ulcers healed rapidly, there has been no recurrence, and the scars were sound. In all, the patient was absent from duty for nine days.

Case 3.—An able seaman aged 22 sustained an incised wound of the pulp of the left hallux while walking barefoot over a coral reef. Four days later the toe was swollen and painful and the whole area was red and tender. A wide incision was made which discharged thin grey serous pus. On culture this gave pure colonies of *Staph. albus*. Kaolin poultices were applied six-hourly and the cellulitis disappeared in 24 hours. The wound was then dressed with magnesium sulphate in glycerin solution six-hourly. In three days the condition was almost completely healed and the patient returned to full duty. A sound and painless scar was obtained.

Case 4.—An able seaman aged 37 sustained four puncture wounds of the lateral malleolus of his right ankle on a reef. They were about 0.5 cm. in diameter and 0.2–0.5 cm. in depth. When seen 10 days later there was considerable cellulitis of the area and a few streaks of lymphangitis on the lateral aspect of the lower leg. All the ulcers were discharging a thin grey serous pus. Treatment consisted in poulticing for 36 hours

followed by magnesium sulphate and glycerin dressings for six days. The condition rapidly subsided.

Case 5.—A lieutenant aged 22 received numerous coral wounds of both feet. Examination three days later revealed six puncture wounds of the soles, heels, and toes of both feet. All the wounds were closed and were surrounded by areas of cellulitis which were extremely tender on pressure. Culture of pus gave pure colonies of *Staph. albus*. It was necessary to incise many of the ulcers, as there were signs of underlying pus, which was scanty and serous. Magnesium sulphate in glycerin solution was then applied. The patient was also given a 30-g. course of sulphathiazole and 400,000 units of penicillin intramuscularly. The condition rapidly healed, and he was discharged to duty 14 days after reporting sick. He was ambulant throughout treatment. One month after discharge he sustained a fresh coral puncture wound of the lateral aspect of the right ankle. This ulcer was discharging a grey serous pus. It measured 0.5 cm. in diameter and 0.3 cm. in depth, and was surrounded by an area of cellulitis 5 cm. in diameter. Treatment was by applications as in the other cases. The condition cleared up rapidly. Culture of the pus obtained gave pure colonies of *Staph. albus*.

Case 6.—An electrician's mate aged 20 sustained a coral puncture wound of the lateral aspect of the right ankle 14 days before being examined. On examination there was a circular ulcer about 0.8 cm. in diameter and about 0.5 cm. in depth, posterior to the lateral malleolus of the right leg. There was a large surrounding area of cellulitis and tracking lymphangitis of the lateral aspect of the leg. The ulcer was extremely tender on pressure, but was closed over by a thick scab. There were no signs of underlying pus. The area was poulticed with kaolin six-hourly for a period of 24 hours, when it became apparent that there was underlying pus. The scab and surrounding skin were excised and a small collection of grey serous pus was released. Penicillin, three doses of 200,000 units, was injected. The patient returned to duty five days after the beginning of treatment. A sound scar was obtained.

Case 7.—A leading seaman aged 21 received numerous coral puncture wounds of both ankles three days before examination. All were septic and discharging a thin grey pus. Several of the wounds were surrounded by small areas of cellulitis, but none was severe. There was no evidence of lymphangitis. Treatment was by magnesium sulphate and glycerin dressings. The patient was discharged to full duty two days later. A sound scar was obtained in each lesion.

Conclusions

It seems that silica-headed darts released by the cnidoblast cells of the coral polyp enter into the wounds or under unbroken skin. It is possible that small pieces of coral containing many polyps may be introduced into the wound.

These darts release a toxic fluid which is capable of producing complete paralysis in small marine animals. This fluid almost certainly irritates human tissues. At the same time the silica-headed darts produce a foreign-body reaction which results in hyperaemia in the area as well as the pouring in of leucocytes.

The wound is invaded by secondary infectors—that is, the normal inhabitants of the skin, *Staph. albus*. This was the only organism isolated from the ulcers.

Byrne suggests that a deficient diet aids the formation and delays the healing of coral ulcers. In my series all personnel were living on a standard diet with a daily average intake of 3,600 calories. At the same time they had ample supplies of fresh vegetables and the vitamin intake was supplemented by compulsory rations of lemon juice and canned fruit. Except for those suffering from coral ulcer, the members of the survey party returned to the ship in a much fitter state than when they left to go ashore. They had facilities for regular daily exercise denied to those left aboard, lack of recreational space being severely restricted in a small ship.

Byrne also suggests that the intake of alcohol may delay healing and may be a factor in producing the condition. The patient in Case 1 was almost a teetotaler, and Case 2 was under age and unable to draw his "tot" of rum. These cases were the most severe of the series and both required treatment in bed. The climate seems to have had little effect, as the two months in question—January and February—are the coolest in the Persian Gulf.

Coral ulcer would probably be prevented by the provision of special protective footwear (the present jute-soled coral shoes are entirely inadequate) and by the education of personnel in the dangers of the condition.

Summary

The condition "coral ulcer" is discussed with reference to its occurrence among officers and ratings of H.M.S. *Challenger* during a recent survey in the Persian Gulf. The life history of the coral polyp is discussed and its peculiar feeding mechanism described. Seven cases of the condition are reviewed and their aetiology, course, and treatment described. The need for efficient coral shoes is emphasized.

I am indebted to Mr. R. M. Ramsden, resident geologist, Petroleum Development (Qatar) Ltd., Dukkan, Persian Gulf, for tracing the life history and feeding habits of coral; to Dr. G. F. N. Anderson, senior medical officer of the same company, for notes on cases; to Mrs. Hills, bacteriologist, Bahrain Government Hospital, who performed all the bacteriological work; to Mr. T. J. Shields, librarian of the British Medical Association, who searched the literature on the subject and dispatched all his notes to the Persian Gulf by air; to Lieutenant D. A. Wiltcher, R.N., for notes on the coast of Qatar; to Sick-Berth Attendant E. Owens, of H.M.S. *Challenger*, for treating the cases; and to the Medical Director-General of the Navy for permission to publish this paper.

BIBLIOGRAPHY

- Bonnevie, P. (1948). *Acta allerg.*, **1**, 40.
 Byrne, K. (1924). *Med. J. Aust.*, **2**, 649.
 Carpenter, A., and Barker, D. W. (1926). *Nature Notes for Ocean Voyagers*, p. 105. London.
 Herdman, Sir W. A. (1923). *Founders of Oceanography*, p. 202. London.
 Levin, O. L., and Behrman, H. T. (1941). *Arch. Derm. Syph.*, **Chicago**, **44**, 600.
 Manson-Bahr, P. H. (1940). *Manson's Tropical Diseases*, p. 846. London.
 Paradise, W. E. J. (1924). *Med. J. Aust.*, **2**, 650.
 Persian Gulf Pilot, 1942, Hydrographic Department, Admiralty.
 Sverdrup, H. U., Johnson, M. W., and Fleming, R. H. (1942). *The Oceans*, pp. 319, 854. New York.
 Thomson, Sir C. W., *Scientific Reports on the "Challenger" Expedition, 1872-1876*.

The United States Army's health was better in 1949 than it had ever been, said Major-General R. W. Bliss, Army Surgeon-General, recently. "The U.S. Army to-day is not only the healthiest army in the world, but the healthiest in all history." He gave figures to show that the rate of admissions for 1949 was 128 per 100,000 strength per average day. "Admissions" includes not only hospital patients but also all persons relieved from duty because of illness or injury beyond the day of onset. The 1949 report shows an improvement in Army health for the fourth consecutive year since the end of hostilities, and compares favourably with an average wartime rate, excluding battle casualties, of 202 admissions per 100,000 per day. Since then there has been a steady decline, the average daily rate being 178 in 1946, 174 in 1947, and 132 in 1948. The Army report includes rates for the Air Force for the first half of 1949, as well as for the Army for the entire year. The Air Force set up its own medical service last July, and began its own system of health reporting then. General Bliss referred also to a consistent decline in the death rate, particularly in deaths from disease. The 1949 figures for total deaths were 200 per 100,000 strength per year, against 220 for 1948 and 230 for both 1946 and 1947. There were 50 deaths from disease per 100,000 per year in 1949, 60 in 1948, 70 in 1947, and 80 in 1946.