to keep body and tobacco odours at acceptable levels. When they used activated carbon filters with air cooling even 1 cubic foot (0.03 cubic metre) per man per minute was found to be adequate, and carbon dioxide, carbon monoxide, bacteria, and dust did not reach "noxious or objectionable levels." In the United States Navy a fresh air supply of 5 cubic feet (0.15 cubic metres) per man per minute is the minimum required by design for air-cooled compartments, although, for other reasons, this amount is usually exceeded in practice. In the Royal Navy at least 10 cubic feet (0.3 cubic metre) per man per minute is supplied in air-cooled compartments when the cooling is in operation. For compartments with normal ventilation an allowance of 10 cubic feet (0.3 cubic metre) per man per minute is added to the amount which is calculated to be necessary to get rid of the heat within the compartment. The total quantity must be equivalent to at least 30 cubic feet (0.9 cubic metre) per man per minute.

Little is known about the effects of prolonged or repeated residence in a totally enclosed space. There is no obvious reason why serious adverse effects, other perhaps than those of a psychological nature, should occur if the equipment for controlling the temperature and composition of the air is efficient and is used correctly. However, ill effects due to the contamination of air by harmful chemicals were not very uncommon in the Navy in wartime, particularly when ventilation was restricted (Weiner and Thomson, 1947; Ellis, 1952c). The possibility should not be forgotten that in an unventilated or poorly ventilated space small amounts of contaminants, such as the breakdown products of fuels, lubricants, paints, or similar chemical substances, which are innocuous in a ventilated compartment, may affect men adversely if exposure is prolonged or repeated.

Conclusion

The environmental health of a community contributes to what Richmond (1947) has termed its "positive health." Serious defects in the environment may not be reflected by obvious "negative health." It is thus advisable to supplement the bald records of sickness in the Navy by measuring the environmental factors and relating these measurements to established criteria of what is or is not desirable. New instruments and techniques are helping to close many of the gaps which hampered this work in the past; and, largely as a result of the stimulus of the Royal Naval Personnel Research Committee, firm answers are being obtained to many questions which were formerly controversial. The requirements of the men must be appreciated against a complex background of material needs and tactical situations, and this is the task of various working groups and panels, which include not only leading scientists and naval medical officers but representatives of the Naval Staff, the Admiralty Materiel Departments, and the Naval Scientific Service. This arrangement provides a powerful but flexible instrument with which to tackle the many problems of the ever-changing naval environment, to only a few of which I have referred here.

This account is published by the kind permission of Surgeon Vice-Admiral Sir Alexander Ingleby-Mackenzie, the Medical Director-General of the Navy. The data in the Chart are abstracted from an unpublished report to the Royal Naval Personnel Research Committee by Surgeon Lieutenant-Commander R. T. John, Royal Navy, Dr. R. K. Macpherson, Mr. P. S. B. Newling, and myself.

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POST-TRAUMATIC INOCULATION TUBERCULOSIS

WITH A REPORT OF A CASE OF TUBERCULOUS INFECTION IN A SCALP WOUND

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Tuberculous infection in a skin wound is a rare but well-known condition. Of 2,114 cases of primary tuberculosis reported by various investigators, Ghon and Kudlich (1930) found 3 (0.14%) to be primary tuberculosis of the skin. Sallick (1939), reporting a case of probable primary inoculation tuberculosis of the skin, stated that a recognized example of this condition had never been seen before at the Mount Sinai Hospital, New York. The commonest sites for this condition are the fingers and the dorsum of the hand, and one of the earliest cases reported, by Tscherning in 1888, was that of a servant who contracted tuberculous infection in a finger, with subsequent lymphatic involvement, after wounding the finger on a sputum cup used by a tuberculous master. The local lesion is given several names—post-mortem wart, dissection tubercle, anatomical tubercle, pathologist's wart, and verruca necrogenica

(tuberculosis verrucosa cutis). The condition is said to be more common in members of the medical profession, butchers, veterinary surgeons, and milkmaids.

Literature

Stokes (1925), Michelson (1935), and Grady (1951) have reviewed the literature on the subject. Stokes had found that 70 cases had been reported up to 1925, and he described 10 additional cases which he had seen at the Mayo Clinic in the eight years previous to 1925. *Verruca necrogenica* is usually interpreted as a tuberculous superinfection—that is, a local skin lesion without lymphatic involvement occurring in a previously infected person. This belief cannot be strictly adhered to, as cases of tuberculous inoculation of the skin, with lymphatic metastases, have been reported in adults who are likely to have been previously infected. Bruusgaard (1934) states that, typically, the primary skin complex occurs in a previously uninfected person and consists of a local lesion with definite and marked lymph-node involvement, and frequently with marked lymphangitis.

Stokes (1925) states that tuberculosis verrucosa cutis and primary inoculation tuberculosis can be easily differentiated clinically. The secondary lesion consists of an inflammatory reaction in the upper corium with verrucous changes in the epidermis, the macroscopic lesion being a horny inflammatory papule with villi on the surface; it is often possible to express pus from between the villi. The primary lesion, often inconspicuous, consists of a well-defined tubercle situated rather deeper than in the secondary type, with less general tissue reaction. Clinically, the lesion is flat or slightly raised, and consists of miliary nodules surrounding a slightly depressed scar or ulcer; it is usually covered by a crust, and when this is removed a purulent discharge occurs and fine granulations are seen to be covering its floor; it has a slightly undermined edge and there may or may not be "apple-jelly" nodules in its floor; and there is a marked tendency to caseation and liquefaction in the involved lymph nodes.

Although cases of tuberculous inoculation of the skin have been reported in the literature, we have not seen a reference to tuberculous infection in a scalp wound, and we report a probable case of tuberculous infection in such a wound.

Case Report

A boy aged 9 years accidentally hit his head against a fire hydrant in the street on October 28, 1953, and sustained a deep laceration, about $\frac{1}{2}$ in. (2 cm.) in length, in the right temporal region of the scalp. He attended hospital A, where the wound was closed with one nylon suture and an injection of antitetanus serum was given. The suture was removed on the fifth day and the boy was discharged from hospital on the seventh day, when the wound was healing with a yellow coagulum on the surface.

A swelling was noticed behind the right ear two weeks after the accident, and swellings in front of the right ear and in the upper part of the right side of the neck were observed one week later. On November 28 the boy's mother noticed a swelling in the region of the scalp wound, apparently containing pus. The patient was again seen at hospital A the next day. Glycerin and magnesium sulphate dressings were applied daily to the wound area, and penicillin was given by intramuscular injection daily for eight days, with no improvement in the condition. Chloramphenicol capsules, 0.25 g. four times a day orally, were then given for one week, but there was again no apparent response to treatment.

The patient attended hospital B on December 14; the scalp wound was discharging pus, and the right pre- and post-auricular and right upper deep cervical lymph nodes were enlarged. X-ray examination of the chest showed doubtful early glandular enlargement at the right hilum; the Mantoux test, 1:1,000, was strongly positive, and the E.S.R. was 5 mm. in the first hour (Westergren). Dry

dressings were applied to the wound, which was apparently healed on December 23. He was again seen on January 20, 1954, when the wound was discharging again slightly and the adenitis was still present. A further x-ray examination of the chest showed no definite evidence of glandular enlargement and the lung fields were clear.

An intermittent discharge from the scalp wound persisted, and the patient was referred by his doctor to the Liverpool Stanley Hospital on February 23. The almost vertical wound in the right temporal region of the scalp was healing, but infection was present, with thickening at the extreme upper end of the wound, and there was a slight discharge of thin yellow pus from the wound. Enlargement of the right pre- and post-auricular lymph nodes and marked enlargement of the right cervical lymph nodes were present. The boy's general condition was very good and he had previously been healthy. There was no history of tuberculosis in the family. It was thought that a foreign body might have been present in the scalp wound, so excision of the wound area was carried out on February 24. The operation wound was sutured, and a course of penicillin was given by intramuscular injection. The sutures were removed on March 4, when the wound was soundly healed. The pathologist's report on the excised area was as follows: "Sections showed that there was subcutaneous tuberculosis with caseation at several points; the skin appeared to be involved in one place only; there was also considerable chronic inflammation; there was no evidence of any foreign body."

The patient was admitted to hospital on March 6 for treatment of the adenitis. The operation wound was seen to be soundly healed and there was no induration in the area; the lymph nodes were still enlarged and the right cervical nodes were somewhat matted together. X-ray examination of the chest showed no evidence of pulmonary disease. Examination of the blood showed: red cells, 5,000,000 per c.mm.; haemoglobin, 100% (14.8 g.); colour index, 1; white cells 10,000 per c.mm. (polymorphs, 65%, lymphocytes 33%, monocytes 2%); the Wassermann reaction was negative. No tubercle bacilli were seen on microscopical examination of the urine and there was no growth after six weeks' incubation on Löwenstein culture. The sedimentation rate was 5 mm. in the first hour (Wintrobe). Streptomycin, 0.5 g. twice daily by intramuscular injection, and para-aminosalicylic acid, 1.5 g. orally five times daily, were given for four weeks; thereafter treatment was continued with streptomycin, 0.5 g. twice daily, and isoniazid, 50 mg. orally thrice daily, from May 10 for four weeks.

During this treatment the lymph nodes became larger and were adherent to the skin, and a collar-stud abscess developed below the right angle of the mandible. Incision and curettage of the right pre-auricular lymph node was performed; yellow pus and caseous material were evacuated, and para-aminosalicylic acid cream was instilled into the operation wound; the collar-stud abscess was excised and dissection of the right posterior auricular lymph node and the upper right cervical lymph nodes was performed. A corrugated rubber drain was placed in the neck wound and was left *in situ* for two days; the skin wounds were closed with sutures, these being removed on the fifth day. The pathologist's report on the material obtained from the right pre-auricular lymph node was as follows: "Amorphous debris; few acid- and alcohol-fast bacilli present, morphologically indistinguishable from tubercle bacilli." Löwenstein culture produced no growth after six weeks' incubation. The pathologist's report on the lymph nodes removed from the neck was: "These glands show the typical gross and microscopical appearances of tuberculosis; there is much caseation."

The wounds healed satisfactorily and the patient was discharged on June 4. The wounds have remained soundly healed and the patient was in good health twelve months after the accident.

Discussion

Stokes (1925) stated that the complete substantiation of the diagnosis of primary cutaneous inoculation tuberculosis requires the following conditions to be fulfilled: "apple-jelly" nodules in the gross lesion, tubercle bacilli in the smear, negative culture for actinomyces and sporothrix in the pus and tissue from both the primary lesion and the involved lymph nodes, and the demonstration of tubercles in the excised tissue from the primary focus and the involved lymph nodes. He stated that in practice it is difficult to make this chain of evidence complete. He considered that the finding of a focus and presumptive extension to the lymphatic drainage area, with the presence of "apple-jelly" nodules in the primary focus, and the histological demonstration of tubercles in the excised tissue from both the primary focus and the regional lymph nodes, in the absence of other systemic foci of tuberculosis, make the diagnosis of primary inoculation tuberculosis reasonably sound. Bruusgaard (1934) states that the latter diagnosis is justified in the presence of a primary sore with lymphangitis and enlarged regional lymph nodes, the nodes rapidly softening, particularly in a previously healthy child.

In our case the histological examination of the excised scalp lesion and of the excised lymph nodes showed the typical appearances of tuberculosis: acid- and alcohol-fast bacilli were seen in the material removed from the right pre-auricular lymph node—there was no growth on Löwenstein culture and animal inoculation was not possible at the time. The appearance of the lesion was consistent with that of a tuberculous granuloma, and the Mantoux reaction was positive. No other focus of tuberculosis was detected. It must be remembered that the condition can be confused with that of lupus vulgaris, syphilitic chancre, sporotrichosis, actinomycosis, and epithelioma; a foreign-body reaction was eliminated by the absence of any foreign body and by the typical tuberculous appearance with caseation.

It cannot be certain whether or not the tuberculous infection was a primary one. Stokes (1925) has pointed out that subsequent lymphatic involvement does not necessarily warrant a diagnosis of primary tuberculosis inoculation, and Grady (1951) described two cases of tuberculous skin inoculation with glandular involvement in patients who were known to have been previously infected (one patient was shown to have an old Ghon lesion on x-ray examination of the chest and the tuberculin reaction was previously positive, while the tuberculin reaction was known to have been previously positive in the second case). On the other hand, Grady described lesions without glandular involvement in three patients who were presumed to have a negative tuberculin reaction prior to the development of the lesion. In our case the tuberculin reaction before the accident was not known. In view of the age of the patient, the subsequent lymphatic involvement, and the absence of any other definite tuberculous focus it is probably correct to describe the case as primary inoculation tuberculosis. It is interesting to compare the sequence of events in this case with those occurring in primary inoculation tuberculosis following ritual circumcision (Reuben, 1917; Holt, 1913). In those cases an indurated area appeared on the prepuce or fraenum from one to two weeks after circumcision, and an ulcer persisted; the inguinal lymph nodes became enlarged after two to three weeks, and the involved nodes often began to break down after about two to three months. The sequence of events was somewhat similar in our case.

The source of infection in our case is debatable. It is often from contaminated objects, the tissues of infected animals, or tuberculous sputum, but in children it is usually from the parents—particularly the mother. It is possible that tubercle bacilli were present on the fire hydrant, a tuberculous patient having spat on it, or infection may have come from a tuberculous person at some time after the accident. There was no history of tuberculosis in the family. Hellerström (1952) and others reported a series of cases with lesions resembling lupus vulgaris following

abrasion of the skin occurring in swimming-pools; our patient had not been swimming and could not have acquired the infection in this way. It is possible that tuberculous bacteraemia was present at the time of the accident and that the traumatized area provided a ready nidus for the infection.

Carter and Smith (1935) have pointed out that often it is the adenopathy which brings the patient to the doctor, and the primary lesion may be inconspicuous. Stokes (1925) warns us that such an overlooked primary focus may be responsible for repeated recurrence of adenitis; he states that delayed adenopathy after even a trivial wound demands careful examination of the area drained by the involved glands for a possible focus of tuberculous inoculation.

X-ray therapy was used in the past; this increased fibrous reaction around the lesion and encouraged healing by the formation of scar tissue, but it also encouraged abscess formation in lymph nodes which were approaching liquefaction. Grady (1951) stated that surgical excision of the skin lesion and of all other diseased tissue gave the most rapid and satisfactory results, that streptomycin was a useful adjunct to surgery, and that streptomycin or other antituberculous drugs, either alone or in conjunction with surgery, are helpful in healing the disease. Stokes (1925) also stated that excision of the primary focus and the involved lymph nodes was the best treatment. He advised that the lesion should be widely excised and that dissection should be carried out as deep as the fascia, and stated that x-ray therapy may not destroy the primary focus or retard its "feeder" activities. In our case the lesion was excised four months after the accident, and its tuberculous nature was realized only at that time; a course of streptomycin and P.A.S. was given for one month, and then streptomycin and isoniazid were given for a further month. Excision of the involved lymph nodes was necessary. It is possible that surgical intervention would have been unnecessary if the tuberculous nature of the condition had been realized earlier.

Summary

Tuberculous inoculation of skin wounds is briefly described.

A case of probable primary tuberculous infection of a scalp wound is reported; cure was effected by a combination of antituberculous drugs and surgery. It is noted that earlier recognition of the tuberculous nature of the lesion might have made surgical intervention unnecessary.

It is emphasized that tuberculous infection in a wound should be looked for when adenitis follows a wound, however trivial—especially when the adenitis recurs.

Streptomycin in combination with P.A.S. or isoniazid should be used in all cases. Excision of the local lesion, which may act as a "feeder" of tubercle bacilli, is advisable, and excision of involved lymph nodes may be necessary.

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