BRITISH MEDICAL JOURNAL

LONDON SATURDAY MAY 10 1941

PULMONARY TUBERCULOSIS IN RECRUITS

FURTHER EXPERIENCE IN A SURVEY BY THE METHOD OF MINIATURE RADIOGRAPHY

BY

DOUGLAS GALBRAITH, M.D., F.R.A.C.P.

Major, Deputy Assistant Director-General of Medical Services, Australian Army Medical Corps

To judge by the correspondence in the medical journals that has followed the paper on this subject by Lieut.-Colonel E. L. Cooper (1940) the use of the method of miniature radiography by the Australian Army for the routine chest examination of recruits has created wide interest. The number of examinations during 1940 was more than 100,000, and it seems worth while to place the results on record. The most important reason, however, for a progress report on the subject is that striking confirmation of the value of this work has been obtained by Dr. Reginald Webster, pathologist to the Melbourne Children's Hospital, whose detailed results are recorded on page 701. Dr. Webster has had outstanding experience in this field, and the results of his investigation represent a considerable contribution to tuberculosis research. While there must always be a scientific doubt in regard to the radiological diagnosis of tuberculosis, there can be little objection to a diagnosis established by sound bacteriological methods.

Cost of Method.—Careful figures of cost have been maintained throughout in all the military commands. The cost per recruit has consistently averaged between 5d. and 6d. This figure covers cost of all films, miniature and 14 by 17 inch, cost of processing, wages of staff, and salaries of specialists. A liberal allowance for maintenance and for depreciation of plant brings the total cost for each recruit to an average of 10d.

Survey of Results and Value of the Survey

From the various military commands in Australia the results of the examination of more than 100,000 Army recruits are available. All these recruits had passed the clinical medical examination. Of this number 1.04% showed radiological evidence of active or latent tuberculosis of the reinfection type, thus representing rather more than 1 in 100 of those examined. In 0.56%, or rather more than 1 in 200, the condition was regarded as being active. These figures approximate very closely those reported by Lieut.-Colonel E. L. Cooper for the first 22,000 recruits examined. For obvious reasons the exact number of recruit examinations cannot be given, but it can be stated that considerably more than 1,000 recruits showed radiological evidence of active or latent tuberculosis of the reinfection type. In addition approximately 1 in 400 showed non-tuberculous pulmonary

conditions on the radiograph and 1 in 1,000 had cardiac or vascular abnormalities. The detailed results are given in Appendix I.

Disregarding the humanitarian aspect and examining the problem strictly from the Army standpoint, the most important factors which operate when a soldier develops active tuberculosis are: (1) the loss of his services and of the work hours spent in giving him his military training; (2) the danger of his infecting others in the close proximity entailed in hutments and tents; (3) the financial loss to the taxpayer represented by the cost of treatment and by pension. The first factor is self-evident and need not be stressed. The second is dealt with convincingly by Dr. Reginald Webster. The factor of financial loss is not so clearly recognized. Two statements should suffice to give the necessary emphasis. The first is that, as quoted by Lieut.-Colonel Cooper, the cost in pensions and treatment of tuberculous soldiers of the First A.I.F. (1914-18) amounted in 1938 to approximately half a million pounds. The second is that the Department of Repatriation has found that in Australia in the last war the average cost of each ex-soldier with pulmonary tuberculosis has approximated £3,000. These figures should make clear the saving in cost by the sifting out of tuberculous recruits. It should be noted, too, that in addition to those cases developing active tuberculosis, repatriation experience has shown that many, if not all, of those soldiers with latent lesions who have developed pulmonary symptoms of any kind in the succeeding years have been regarded as eligible for treatment and pension.

Criticism of the Method of Miniature Radiography

Criticisms have fallen under two main headings—medical and administrative: (1) that the method of miniature radiography is not accurate enough, and that cases will be missed; (2) that because of delay in recruiting the method is impracticable as an Army measure.

1 (a). *That Recruits with Tuberculosis are Missed.*—While it is at once admitted that the miniature film is not as good as the full-size film and will not pick up 100% of early lesions, the degree of accuracy reached by experienced observers is very striking. Subsequent personal comparison of several hundred 14 by 17 inch films has inspired admiration for the "spotting" ability of the teams examining the miniature films. But occasional failure to recognize an early lesion would not seriously detract from the value of a method which has so

efficiently sifted out such a large number of cases. Three other methods of routine radiographic examination have been advocated by critics of the miniature films. These are:

(i) *Fluoroscopy*.—The time consumed is great and there is no permanent record—an important point in regard to the question of pensions.

(ii) *Use of the Full-size Film*.—The expense of this method is very high and much more time is required for taking, developing, and viewing the film.

(iii) *Use of the 5 by 4 inch Film*.—This eventually may be the method of choice, although a recent demonstration arranged in Melbourne by the Watson Victor X-Ray Company, in which miniature, 5 by 4 inch, and 14 by 17 inch films were compared, did not demonstrate any appreciable margin of superiority of the 5 by 4 inch film over the miniature film. Most of us who saw the demonstration preferred the miniature film.

Edwards (1940) complains that claims have been made that the question of the activity of a lesion can be decided on the miniature film. Lieut.-Colonel Cooper in his article clearly states that "the activity of a tuberculous lesion can rarely be determined upon a small film alone." In the Australian Army any attempt at radiological diagnosis of activity is made on examination of the subsequent 14 by 17 inch film. The basis function of the miniature film is to reduce the number of large films necessary. The criticism by Brailsford (1940) that many cases of pulmonary tuberculosis are detectable by clinical methods at a stage where there is no radiological evidence, although not a criticism of the miniature method, should be mentioned. D'Arcy Hart (1940), in reply, has inquired where such a series of cases has been published. Dr. Reginald Webster's observation of the finding of tubercle bacilli in three cases from which radiological evidence and clinical evidence were absent does, however, give cause for reflection and for further investigation. On the other hand, few clinicians experienced in tuberculosis would claim that any large number of recruits with clinical tuberculosis will have a completely normal chest radiograph.

1 (b). *That Non-tuberculous Recruits are Diagnosed as Tuberculous*.—Every recruit rejected as the result of x-ray examination is referred to the civil tuberculosis department for full investigation and treatment if necessary. Here the diagnosis is reviewed, and there is ample time for investigation and observation. This eliminates the possibility of wrongly labelling a man tuberculous.

2. *That Routine Radiography of Recruits is Impracticable because of the Delay occasioned in Recruiting*.—The report of the committee appointed by the Minister of Labour and National Service under the chairmanship of Lord Horder (1940), while expressing its opinion that the adoption of the method of miniature radiography represents the ideal to be aimed at in the medical examination of the armed Forces, stated that it is impracticable at the present time "because of lack of apparatus, lack of sufficient numbers of expert examiners, and because the inclusion of this form of examination would seriously delay the medical examination of recruits." Unremitting perseverance by a small group of enthusiasts, headed by Lieut.-Colonel Cooper and strongly supported by the Director-General of Medical Services, has in Australia overcome these very real difficulties. The Army now possesses ten units for miniature radiography, one of which forms a mobile unit in a train and travels great distances in Queensland. The whole of this apparatus, with the exception of x-ray tube, timer, and camera, has been manufactured in Australia. A team of keen experts has been gathered in each city, and there has been no hold-up of recruiting. Results of miniature films are available in as short a period as six hours. The maximum period allowed for obtaining results of miniature films is thirty-six hours. Approximately 97% of recruits can leave the recruit reception depot on receipt of this result. The other 3%, for whom large films have been ordered, have these taken immediately. The results are available within

twenty-four hours, and the men are at once brought before the Specialist Board. Finality in regard to suspects is therefore reached within three days, and in most cases within a maximum period of seven days. Only occasionally is it found necessary to await the result of cultural tests. Details of procedure are given in Appendix III. The fact that the method has now been adopted by the Royal Australian Navy and the Royal Australian Air Force demonstrates its practicability. In both these services the result of several thousand radiological examinations shows approximately the same incidence rate of active tuberculosis as in the Australian Army—that is, about 1 in 200. Recently authority has been granted to carry out a radiological chest survey of internees in Australia.

Summary

More than 100,000 recruits of the Australian Imperial Forces have been subjected to routine chest x-ray examination by the method of miniature radiography.

One in every 100 has shown radiological evidence of active or latent tuberculosis, and 1 in every 200 of active tuberculosis.

The diagnosis of tuberculous infection has in a large number of cases been substantiated by bacteriological investigation, the results of which are given in this issue in a report by Dr. Reginald Webster.

A considerable number of instances of non-tuberculous pulmonary pathology and of cardiac and vascular lesions have been observed.

The results here given represent simply a summary of a very great deal of work done by members of the A.A.M.C., including medical officers, technicians, and staff, throughout Australia. The opportunity is appreciated of being able to acknowledge the enthusiasm and efficiency with which this work of considerable national importance has been carried out in every command in the Commonwealth. Valuable co-operation has been given by Stamford X-Ray Company and Watson Victor X-Ray Company.

APPENDIX I

Results of Analysis

Recruits examined by miniature radiography	Over 100,000
No. of 14 by 17 inch films ordered.....	2.74%
No. of films showing evidence in lung fields of past or present tuberculous infection of the secondary adult type of tuberculosis	1.04%
No. of recruits showing radiological evidence of active pulmonary tuberculosis	0.56%
No. of recruits showing fibrotic or calcified areas in the lung field suggesting a healed or quiescent lesion	0.47%
No. of recruits showing radiological evidence of non-tuberculous pulmonary pathology	0.25%
No. of recruits showing radiological evidence of cardiac or vascular lesions	0.12%

APPENDIX II

The Unit for Miniature Radiography

This remains substantially as it was described by Lieut.-Colonel Cooper in Appendix I of his original article. An improved Contax camera is now used. This is fitted with an f/1.5 lens and auxiliary lens. The latter permits accurate focusing at the short screen-film distance and is mounted on a special adjustable mounting-plate. The camera has been altered to provide locking facilities on both the lens aperture and the lens focus. Operation of the shutter has been eliminated, the shutter remaining open at all times, and the film being merely wound on one complete frame after each exposure has been made. The camera case has been supplied with a special mounting-plate, arranged for easy removal or fitting. The construction of the mounting assembly is such that there is no necessity to re-focus the camera at any time.

Experience over the past twelve months has brought about a definite improvement in the quality of the end-results, mainly due to two factors:

(a) Improved dark-room processing technique of the Super XX film.

(b) Improved projection facilities. Experience has shown that the image is best projected with a projector of the

400-watt type on to a screen made of a sheet of matt-surface bromide photographic paper which has been fixed, and of a projection-screen size not exceeding 10 by 12 inches, framed with a flat black mask, thus eliminating unwanted reflection from the edges of the projection screen. It is sometimes found helpful to view doubtful lesions through opera-glasses.

It is anticipated that film manufacturers will specially develop a film for miniature radiography with the object of increasing the speed of the emulsion to the particular luminosity given off by the fluorescent screen and of providing greater contrast in the image recorded on the photographic emulsion. Lag in the fluorescent screen has no detrimental effect, and in fact enables the actual exposure time to be reduced. For miniature radiography the apparatus is operated at 50 mA 85 kV, with exposure times in the order of 0.5 second.

Tube and maintenance costs have been comparatively minor items, due, we believe, to the fact that excessive milliamperages that could not safely be used when operating at high speed even with fully rectified equipment have not been employed. Little alteration has been found necessary in the clerical and radiographic procedure originally adopted. At some centres where line conditions are not ideal, the fitting of a constant current stabilizer ensures greater uniform density in resulting miniatures, and provides a further safeguard against tube overload.

APPENDIX III

Procedure Employed

In the main this is as laid down in Appendix II of Lieut.-Colonel Cooper's original paper. In order to bring the result of the chest radiograph into the same category as the blood group and the results of vaccination and inoculation, steps are being taken to have an appropriate entry recorded in each soldier's paybook.

The following is a summary of the procedure in regard to each recruit:

1. On completion of the ordinary medical examination, which is a very thorough one, the applicant goes into an adjoining room and has the chest radiograph taken on the unit for miniature radiography.

2. All miniature films taken up to 3 p.m. are examined on the same evening by the Viewing Committee, consisting of at least one radiologist and one physician. Films taken after 3 p.m. are viewed the following evening.

3. Recruits are paraded next morning. Those whose films are regarded as beyond suspicion are drafted to units. If any abnormality is detected, or there is a reasonable doubt, a 14 by 17 inch film is at once taken. Approximately 3% of recruits have the large films taken. This film is examined by the Viewing Committee the same day.

4. Those who have had 14 by 17 inch films taken are paraded either on the second day or the third morning. If the film has been passed enlistment proceeds. If not, the man is examined by a Specialist Board appointed for this purpose and consisting of one consulting physician interested in tuberculosis and one specialist in tuberculosis. This examination is in most cases carried out at once. If it has to be deferred the man is drafted to accommodation reserved for this purpose in a camp hospital. The acceptance or rejection of the recruit depends not on the radiological report but on the opinion of this Specialist Board, which reviews the history, the clinical and radiological findings, and in some cases the bacteriological results. If rejected the man is placed under the care of the State Department of Tuberculosis, and his name is notified to this department.

5. In a large number of instances it has been possible to have a complete bacteriological investigation carried out, including culture of sputum or gastric contents.

REFERENCES

- Brailsford, J. F. (1940). *British Medical Journal*, 2, 471.
Cooper, E. L. (1940). *Ibid.*, 2, 245.
Edwards, J. G. (1940). *Med. J. Austral.*, 2, 619.
Hart, P. D'Arcy (1940). *British Medical Journal*, 2, 534.
Horder, Lord (1940). *Ibid.*, 2, 31.

BACTERIOLOGICAL EXAMINATIONS SUPPLEMENTING THE RADIOLOGICAL SURVEY OF THE AUSTRALIAN IMPERIAL FORCE

PRELIMINARY REPORT

BY

REGINALD WEBSTER, M.D., D.Sc., F.R.A.C.P.

*Honorary Major, Australian Army Medical Corps Reserve;
Pathologist to the Children's Hospital, Melbourne*

The present report is published with the approval of the National Health and Medical Research Council of Australia, and at the suggestion of the Director-General of Medical Services, Major-General R. M. Downes, who from the moment of his authorization of the work has followed its progress with a lively and sympathetic interest.

Scope and Objective

In the detection of pulmonary tuberculosis the ultimate and only unequivocal proof is the demonstration of the tubercle bacillus: the necessity for providing bacteriological confirmation of radiological diagnosis whenever possible requires no emphasis.

Many accounts of mass radiological surveys have appeared within recent years, but in the few in which bacteriological findings are mentioned such reference is limited to a statement that a certain proportion of the subjects of the x-ray investigation exhibited a "positive sputum." By this term it is generally to be understood that tubercle bacilli are brought into evidence by the microscopical search of films; but as a means of sifting sputum and other pathological exudates for tubercle bacilli microscopical search is a sieve of very coarse mesh. It has been computed by H. J. Corper (1928) that tubercle bacilli are not detectable in smears until their numbers reach 100,000 per c.cm., whereas guinea-pig inoculation and appropriate methods of cultivation will disclose them in numbers as few as 10 to 100 per c.cm.

To the best of my knowledge the relevant literature contains no record of a large-scale radiological survey supplemented by a concurrent and carefully planned bacteriological investigation of the scope and character which it is the purpose of this report to indicate.

The systematic radiological examination of the entire personnel of the Second Australian Imperial Force, carried out under military discipline, created an opportunity, unprecedented in Australia, of instituting an important and far-reaching public health research. If parallel bacteriological work could be sustained it held promise of providing data upon which to assess the accuracy of microradiographic diagnosis, of being of immediate practical assistance to medical boards, and of elucidating facts regarding the existence and number of "carriers" of the tubercle bacillus among a large and presumed healthy section of the population. This phase of the investigation assumed prime importance when considered in relation to proposals for the eventual extension of thoracic radiography to the civilian community.

In planning the work from the laboratory aspect it was realized that there would be few opportunities of repeating the bacteriological examination for any individual soldier. Both the magnitude of the undertaking and the necessity for working within Army requirements for prompt disposal of the men precluded, in the great majority of instances, more than one attempt to establish the diagnosis of pulmonary tuberculosis on an incontestable bacteriological basis. In view of the serious