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SOME PROBLEMS OF MINIATURE MASS RADIOGRAPHY

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The advent of war found us unprepared not only from the point of view of military equipment but also in the seemingly insignificant means of undertaking mass radiography by the miniature method. Though the results of such methods trickled unceasingly into this country from South America, Germany, and Holland for some years before the war, not until hostilities had started was it appreciated that the method was likely to prove of the greatest value in preventing the enrolment of tuberculous subjects in the Services and in industry. It is idle to complain that we missed the opportunity of importing the necessary type of apparatus, which had carried out many thousands of such examinations in enemy and enemy-occupied territory. Let us rather take consolation in the fact that our own manufacturers have now overcome great difficulties in designing and perfecting apparatus suitable for this work.

The Royal Navy has published the results of the first 18,000 men examined by this means, and it is to be hoped the opportunity will now be taken of establishing this new method in other Services and in industry; for as the war progresses it will become of increasing importance, and without organization the demand will not be met.

While it is true that any *x*-ray plant, fluoroscopic screen, and suitable camera attachment will take a miniature radiograph, there is a vast difference between such a procedure and mass radiography by the miniature method. It must be emphasized that a special apparatus is required for mass radiography, as the machine must be capable of examining cases at the rate of 200 an hour, perhaps even of 1,500 daily. The importance of such speed was emphasized by Rear-Admiral Dudley in his report. There is no doubt that these numbers throw a great strain on the personnel and on the tube, yet this problem is such that machine design must be in alignment with all possible eventualities.

Application of Mass Radiography in War

Though from the surveys carried out by observers abroad useful information can be gleaned on the technical side, the problems to be faced in any attempt to undertake mass radiography by the miniature method in this country differ because of the larger population distributed in a larger number of independent big towns situated in close proximity to each other. The "calling up" for registration purposes, for example, might entail the *x*-ray examination of 500,000 persons within a period of twelve hours, and if each machine examined 2,000 men 250 machines would be required. The cost of these machines, even if they were available, would represent a capital outlay of £250,000 and would cover only a small fraction of the centres where registration takes place. Even if a plant were erected in each county the cost of travelling to it might far exceed the cost of the usual routine film.

The provision of facilities for carrying out miniature radiography in conjunction with the routine medical examination would also involve a large capital outlay—in the neighbourhood of £150,000—and would have the additional disadvantages of limiting the number of men examined daily and of failing to provide the necessary information at the time the medical examination was made. The examination of the young adult females who have recently registered—a most important group of persons especially prone to infection—would have supplied data of great value.

It certainly seems unlikely that any organization for dealing with such large numbers can be developed at the present time. Alternatively there are considerable possibilities of carrying out a smaller scheme that would include the sections of the fighting Services likely to be subjected to the greatest strain. By this method all men would be examined before proceeding for service abroad, and all cadets to be trained for special duties would have the benefit of this additional examination. The advantages to be gained might well be applied to this latter group immediately, using the routine examination until such time as the miniature method is available.

Application of Mass Radiography in Peacetime

It is likely that miniature radiography will play an important part in the routine medical examinations of the community after the war. There is no reason to doubt that the increased incidence of tuberculous disease that became evident after the last war may again become manifest, especially in view of the additional factor of the conditions brought about by aerial warfare. First, facilities can be provided for the examination of all men called up for military service at the age of 20, and there will be no reason why each man should not be re-examined before his discharge. These examinations will supply important information as to the incidence of chest disease in the male population at that age, and the radiographs will provide an invaluable record of the state of the lungs at that time—a record which could be referred to at will by any hospital or medical attendant should the person subsequently develop a chest complaint. Such examinations would depend on the maintenance of conscription after the war.

In civil life in this country the problem would present greater difficulties than those encountered in an undemocratic constitution. It is obvious that such methods would have to be organized and developed on voluntary lines by individual concerns. That this will be done on an increasing scale is not doubted, as it will benefit the health of the employees and be of financial interest to the employer.

Messrs. Phillips and Co. of Einthoven have in the last seven years completed an examination of 100,000 employees and their relatives; during this period the

number of days' sick leave occurring annually in their company as a direct result of tuberculosis has diminished by no less than 71%, and for an expenditure of 88,000 guilders 252,000 guilders had been saved in expenses for sick pay, medical treatment, treatment in sanatoria, and pensions. The examinations have been carried out voluntarily, as they would be in this country, and were extended to include the members of the household of any of the staff, being repeated at intervals of eighteen months. No charge is made for the service.

There is little doubt that a Government Department or industrial concern might have difficulty in persuading all its employees to consent to such an examination, which might have a far-reaching effect on their employment, and some of the more suspect individuals might reasonably avoid being examined. Many months would necessarily elapse before such a scheme could become universal. A start, however, could be made by insisting that all prospective immigrants entering the country were examined; similarly, this regulation might be applied to all new applicants for the Civil Service, including post-office workers, policemen, and school-teachers. All persons returning to duty following a period of sick leave should necessarily be included. In industrial firms the examination of all new employees should be insisted on, with the result that in a few years, with periodic examinations, the incidence of tuberculosis would undoubtedly show a steady fall. This new form of x -ray examination would be of especial benefit to the employers in industries in which a "dust hazard" exists, as by this means any fresh applicant for employment would have his chest record made and the employer would refrain from signing on any man whose lungs showed signs of damage from previous employment. Also, in assessing individuals for life insurance many errors could by this means be avoided.

Through the kind co-operation of Messrs. Stanley Cox, Ltd., we were able to take a small series of miniature radiographs of patients attending the out-patient department of Brompton Hospital in the few days previous to the delivery of the plant to the Services. It was hoped that during this period we should be able not only to compare the miniature film with the routine radiograph but to come to some conclusions as to the type of lesions which might fail to be visualized by the former method. It is unfortunate that during the few days the apparatus was available hardly any of the patients with minimal shadows attended for their periodic routine radiograph, but some idea of the accuracy of the visualization of small areas of infiltration can be gauged from a study of the opposite lung in the cases under treatment by artificial pneumothorax (see Table).

Type of Apparatus Employed

The type of plant was essentially the duplicate of the machine used by the Royal Navy, as reported by Rear-Admiral Dudley and Commander Fitzpatrick (1941). It is fitted with a 10 kW shock-proof tube, the cooling fan of which comes into operation when the temperature rises above a certain critical temperature. The focal screen distance is 86 cm., and the screen-camera distance 76 cm. The special features include an electrically operated camera which brings the new film into position, and automatic illumination to indicate that the device by which the patient's name is photographed on the film has been effective. The latest type of Kodak film was used throughout for these examinations, and no test of speed was attempted. It was, however, obvious that owing to the neat design of the plant patients could be photographed at the rate of 4 a minute, and that it took longer to record the particulars of the patient's name and number than to carry out the radiographic procedure.

Consideration of Technique

In this country mass radiography is only at its beginning, and the few plants in operation are not yet working to capacity. The plant as supplied to the Royal Navy has on occasions achieved 220 examinations an hour.

Observers abroad give full details of their technique and the numbers examined, but provide little information of the time period over which the examinations were carried out and no details of tube life under such circumstances. This latter is of considerable importance in estimating the cost of mass examinations. There are few constant factors in the technique of other workers. In only one instance was a 6 kW tube used. Other workers have employed the 10 kW tube or the rotating anode type. The 10 kW tube used by the Royal Navy has taken 220 photographs in an hour, and it is thought unlikely that the rotating anode tube would be capable of standing up to this speed for long periods. The tube-screen distance is in all cases small in order to minimize exposure time.

The use of a stationary grid is said to improve contrast; but here, again, the grid doubles the exposure time and throws an increased strain on the tube. Nevertheless, the time of exposure is already greatly in excess of that in common use for routine radiography, being for the small patient 0.3 second without a grid. It is to be hoped that the research into the speed of the miniature film will bring about still further improvement in the time factor. Experiments into the optimum combination of screen and film have recently been reported by Stanford (1941).

Miniature radiography will naturally fail primarily in those cases in which routine radiography produces a less efficient result, notably in the large or muscular patient. In this respect Commander Fitzpatrick is to be congratulated on the uniformity of his results. It will also fail in those cases in which fluoroscopy is essential to complete the diagnosis. These cases form only a small percentage of the whole. To what extent miniature radiography will demonstrate the soft minimal lesions of tuberculous disease and the reticular shadows associated with bronchiectasis and other disease should form useful material for investigation, in conjunction with the routine film, in a chest hospital. As against this small percentage of failures, the method will bring under observation the large majority of persons with abnormal shadows in the lungs—persons who may have either indefinite physical signs or complete absence of them.

There is no question of this method acting as a substitute for normal radiography; rather should it be considered an additional means of bringing under investigation a number of symptomless persons who may subsequently be found to have abnormalities in the chest. Errors of commission will be eliminated by routine radiography and medical examination.

Viewing of Films

The problem of viewing miniature films is an important one, quite apart from their interpretation, and it is probable that they should be subdivided into three main groups—normal, abnormal, and inadequate for interpretation. The second and third groups may be found to represent about 5% of the total. A difficulty will be found in the eye-strain involved in reporting. The miniature film when projected does not form so distinct an image as the routine film, and the detail does not improve on close inspection. Though the results can be viewed at leisure one finds that after reporting 100 films in an hour a definite eye fatigue sets in. No such fatigue was noticed after viewing the same full-sized films the next day.

The comparative reports of the miniature and full-sized films (see Table) are appended without comment, as it is realized they are limited in number and not representative of the type which would be encountered in any mass survey.

Table showing Comparative Reports of Miniature and Full-sized Films

6 N = Normal.
 112 ABN = Abnormal.
 1 I = Indeterminate.
 1 X = Errors of commission which would be corrected by routine radiography.
 5 Y = Errors of omission.
 22 O = Cases in which miniature radiograph suggested an abnormality without revealing all the abnormal shadows or their exact nature.

Case No.	Sex	Miniature Film	Full-sized Film
1 O ABN	M	R. Cavity middle zone	R. Consolidation in middle and lower zones, with cavity in middle zone
2 ABN	F	L. Doubtful base	L. Accentuation of striation in lower zone
3 ABN	F	R. pneumothorax	R. Same
4 Y ABN	F	L. Normal	L. Normal
5 ABN	F	R. pneumothorax	R. Same
6 N	F	L. Normal	L. Normal
7 N	F	R. Normal	R. Normal
8 ABN	M	R. Lesion 2nd interspace	R. Consolidation left base
9 ABN	M	R. Opacity at base	R. Pleural thickening in lower zone
10 ABN	M	L. Normal	L. Same
11 ABN	M	R. pneumothorax	R. Normal
12 ABN	M	R. Infiltration upper and middle zones	R. Normal
13 ABN	M	L. pneumothorax with fluid level	L. Normal
14 ABN	M	Poor film	R. Normal
15 ABN	M	R. 1st interspace doubtful	R. Normal
16 ABN	M	L. pneumothorax with fluid level	L. Normal
17 ABN	M	R. pneumothorax	R. Normal
18 O ABN	M	L. Doubtful pneumothorax	L. Normal
19 ABN	M	R. pneumothorax	R. Normal
20 ABN	F	L. Abnormal shadows upper and middle zones	L. Normal
21 ABN	F	R. Apical scarring	R. Normal
22 ABN	F	L. pneumothorax with fluid level	L. Normal
23 ABN	F	R. Apical scarring	R. Normal
24 I ABN	F	L. pneumothorax	L. Normal
25 ABN	F	R. pneumothorax	R. Normal
26 ABN	F	L. pneumothorax with fluid level	L. Normal
27 ABN	F	R. pneumothorax	R. Normal
28 ABN	F	L. pneumothorax	L. Normal
29 ABN	F	R. pneumothorax	R. Normal
30 ABN	F	L. pneumothorax	L. Normal
31 O ABN	F	R. pneumothorax	R. Normal
32 ABN	F	L. pneumothorax	L. Normal
33 ABN	F	R. pneumothorax	R. Normal
34 ABN	F	L. pneumothorax	L. Normal
35 O ABN	F	R. pneumothorax	R. Normal
36 ABN	F	L. pneumothorax	L. Normal
37 O ABN	F	R. pneumothorax	R. Normal
38 O ABN	F	L. pneumothorax	L. Normal
39 ABN	F	R. pneumothorax	R. Normal
40 ABN	F	L. pneumothorax	L. Normal
41 ABN	F	R. pneumothorax	R. Normal
42 ABN	F	L. pneumothorax	L. Normal
43 ABN	F	R. pneumothorax	R. Normal
44 Y ABN	F	L. pneumothorax	L. Normal
45 ABN	F	R. pneumothorax	R. Normal
46 O ABN	M	L. pneumothorax	L. Normal
47 ABN	F	R. pneumothorax	R. Normal
48 O ABN	M	L. pneumothorax	L. Normal
49 ABN	M	R. pneumothorax	R. Normal
50 O ABN	M	L. pneumothorax	L. Normal
51 N	M	R. Normal	R. Normal
52 ABN	M	L. pneumothorax	L. Normal
53 N	M	R. Normal	R. Normal
54 N	M	L. pneumothorax	L. Normal
55 ABN	M	R. pneumothorax	R. Normal
56 ABN	M	L. pneumothorax	L. Normal
57 ABN	M	R. pneumothorax	R. Normal
58 ABN	M	L. pneumothorax	L. Normal
59 ABN	F	R. pneumothorax	R. Normal
60 ABN	M	L. pneumothorax	L. Normal
61 ABN	M	R. pneumothorax	R. Normal
62 O ABN	M	L. pneumothorax	L. Normal
63 O ABN	M	R. pneumothorax	R. Normal
64 O ABN	M	L. pneumothorax	L. Normal
65 ABN	M	R. pneumothorax	R. Normal
66 ABN	M	L. pneumothorax	L. Normal
67 ABN	M	R. pneumothorax	R. Normal
68 ABN	M	L. pneumothorax	L. Normal
69 X ABN	M	R. pneumothorax	R. Normal
70 O ABN	M	L. pneumothorax	L. Normal
71 ABN	M	R. pneumothorax	R. Normal
72 N	M	L. pneumothorax	L. Normal
73 O ABN	M	R. pneumothorax	R. Normal
74 ABN	F	L. pneumothorax	L. Normal
75 O ABN	F	R. pneumothorax	R. Normal

Table showing Comparative Reports—continued

Case No.	Sex	Miniature Film	Full-sized Film
38 O ABN	F	R. Lesion at apex and 2nd interspace	R. Lesion at apex and in 2nd and 3rd interspaces
39 ABN	F	L. pneumothorax	L. Same
40 ABN	F	Bilateral pneumothorax	L. Same
41 ABN	F	"	"
42 ABN	F	R. pneumothorax	R. Same
43 ABN	F	L. Lesion at apex and 1st interspace	L. Infiltration at apex and 1st interspace
44 Y ABN	F	R. pneumothorax	R. Same
45 ABN	F	L. Normal	L. Normal
46 O ABN	M	Poor film	R. Scarring at apex
47 ABN	F	R. pneumothorax	L. Same
48 O ABN	M	R. Infiltration upper and middle zones	R. Normal
49 ABN	M	L. Lesion in upper zone	L. Infiltration at apex and in 1st and 2nd interspaces, with calcifying scar towards lower zone
50 O ABN	M	R. pneumothorax with fluid level	R. Same
51 N	M	L. Apical cavitation	L. Infiltration in upper and middle zones, with apical cavity
52 ABN	M	R. Doubtful right apex	R. Apical scarring
53 N	M	L. Normal	L. Same
54 N	M	R. Emphysema	R. Normal
55 ABN	M	L. ? basal pneumothorax	L. Bifid 8th rib, simulating pneumothorax
56 ABN	M	R. Lesion at base	R. Consolidation in lower zone medially
57 ABN	M	L. pneumothorax in upper zone	L. Consolidation in lower zone
58 ABN	M	L. Scarring in 3rd interspace	R. Bulla simulating pneumothorax
59 ABN	F	R. Normal	L. Apical bulla and scarring in 3rd interspace
60 ABN	M	L. Normal	R. Same
61 ABN	M	R. Normal	L. Normal
62 O ABN	M	L. Apical lesion and pleural involvement at base	R. Infiltration in upper zone and pleural involvement at base
63 O ABN	M	R. Normal	R. Same
64 O ABN	M	L. Normal	L. Normal
65 ABN	M	R. Normal	R. Normal
66 ABN	M	L. Normal	L. Normal
67 ABN	M	R. pneumothorax with fluid level	R. Normal
68 ABN	M	L. Normal	L. Normal
69 X ABN	M	R. pneumothorax	R. Normal
70 O ABN	M	L. pneumothorax	L. Normal
71 ABN	M	R. pneumothorax	R. Normal
72 N	M	L. pneumothorax	L. Normal
73 O ABN	M	R. pneumothorax	R. Normal
74 ABN	F	L. pneumothorax	L. Normal
75 O ABN	F	R. pneumothorax	R. Normal

Table showing Comparative Reports—concluded

Case No.	Sex	Miniature Film	Full-sized Film	
76	ABN	F	R. Infiltration upper and middle zones L. Pneumothorax	R. Same L. Pneumothorax with apical cavity
77	ABN	F	R. Lesion 5th interspace L. Pneumothorax	R. Same L. "
78	ABN	i	R. " " L. Doubtful 1st interspace	R. " " L. "
79	ABN	M	R. Normal L. Pneumothorax	R. " " L. "
80	ABN	F	R. Normal L. Pneumothorax	R. " " L. "
81	ABN	M	R. Apical pneumothorax L. Normal	R. " " L. "
82	ABN	M	R. Infiltration upper and middle zones L. Normal	R. Fibrosis and infiltration upper and middle zones L. Same
83	Y ABN	F	R. " " L. " "	R. " " L. Calcified scar at apex overlying rib
84	ABN	M	R. Rib resection L. Normal	R. Same L. "
85	ABN	M	R. " " L. Pneumothorax	R. " " L. "
86	ABN	M	R. Normal L. Pneumothorax	R. " " L. "
87	ABN	M	R. Normal L. Pneumothorax	R. " " L. "
88	ABN	M	R. " " L. Normal	R. " " L. "
89	ABN	M	R. Pneumothorax L. Normal	R. " " L. "
90	ABN	M	R. Infiltration upper and middle zones L. Pneumothorax	R. Infiltration upper and middle zones, with cavities below clavicle L. Same
91	ABN	M	R. Normal L. Pneumothorax	R. " " L. "
92	ABN	M	R. " " L. Normal	R. " " L. "
93	ABN	M	R. Doubtful 2nd interspace L. Pneumothorax	R. Lesion in 2nd interspace L. Same
94	O ABN	M	R. Apical scar, 2nd interspace doubtful L. Pneumothorax	R. Infiltration upper and middle zones L. Same
95	ABN	M	Bilateral pneumothorax	Same
96	ABN	M	R. Old pneumothorax L. Pneumothorax	R. Same L. "
97	ABN	M	R. Pneumothorax with fluid level L. Normal	R. " " L. "
98	ABN	M	Bilateral pneumothorax	Same
99	O ABN	F	R. Pneumothorax with fluid level L. Lesion in 2nd and 3rd interspaces	R. Same L. Lesion in 1st and 2nd interspaces
100	ABN	F	R. Normal L. Pneumothorax with fluid level	R. Same L. "
101	ABN	M	Bilateral pneumothorax	Same
102	ABN	M	R. Pneumothorax L. Normal	R. Same L. "
103	O ABN	M	R. Pneumothorax L. 2nd interspace doubtful	R. " " L. Apical scarring
104	O ABN	M	R. Pleural involvement middle zone, Lesion 3rd interspace L. Normal	R. Apical scarring, pleural involvement middle zone L. Same
105	ABN	M	R. Pneumothorax with fluid level L. Normal	R. " " L. "
106	ABN	M	Bilateral pneumothorax	Same
107	ABN	M	R. Doubtful " scar at apex	R. " "
108	O ABN	M	L. Infiltration in upper and middle zones R. Pneumothorax	R. Lobe of azygos vein is present L. Same
109	ABN	M	R. Normal L. Thoracoplasty	R. " " L. "
110	ABN	M	R. Pneumothorax L. Normal	R. " " L. "
111	ABN	M	R. Normal L. Pneumothorax	R. " " L. "
112	ABN	M	R. " " L. Normal	R. " " L. "
113	ABN	M	R. " " L. Pneumothorax	R. " " L. "
114	O ABN	M	R. Doubtful 2nd interspace L. Pneumothorax	R. Scarring in 1st and 2nd interspaces L. Same
115	O ABN	M	R. " " L. Calcification in hilum	R. " " L. Normal. Vascular shadows in hilum
116	Y ABN	M	R. Pneumothorax L. Normal	R. Same L. Scarring in 1st interspace
117	ABN	M	Bilateral pneumothorax	Same
118	Y ABN	M	R. Pneumothorax L. Normal	R. Same L. Scarring at apex and 1st interspace

It is emphasized that the miniature films are less easy to interpret and that the sharpness of detail was not at all comparable to that obtained by the condenser set using a rotating anode tube and an exposure of one-thirtieth of a second. The image was, in fact, reminiscent of that procurable in a chest radiograph of about twenty years ago. However, as can be seen, it sufficed in a large majority of

cases to give the necessary indication of the desirability of carrying out a further examination.

Protection.—It seems likely that it will be necessary to carry out tests with regard to the protection of the persons who are constantly working these machines, as the number of daily exposures may be greatly in excess of those made annually in x-ray departments.

Summary

Miniature radiography may be regarded as an additional means of bringing under investigation symptomless persons who may subsequently be found to have chest abnormalities. A comparison is made of a small number of miniature radiographs with the corresponding full-sized films.

Attention is drawn to the importance of developing miniature radiography at the present time. It is considered likely that after the war miniature radiography will play an important part in routine medical examination of the community.

Some of the difficulties that may be encountered are discussed.

I should like to thank Messrs. Stanley Cox and Co., Ltd., for the loan of their plant, and the medical committee of the Brompton Hospital for their permission to install it; also Dr. R. L. Rawlinson for his helpful co-operation.

REFERENCES

- Dudley, S. F. (1941). *Proc. roy. Soc. Med.*, **34**, 401.
Fitzpatrick, W. G. C. (1941). *Ibid.*, **34**, 406.
Stanford, B. (1941). *Brit. J. Radiol.*, **14**, 128.

TUBERCULOSIS IN RECRUITS

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The increase of tuberculosis among the civilian population of the countries of Europe and the high incidence of that disease in the Services during and after the last war have been well recognized. Tuberculosis in the Services cost the British Empire a very large sum of money in pensions and treatment allowances, but the amount of infection spread by tuberculous men passed as fit and by others with latent disease who developed active tuberculosis owing to the strain of military duties cannot be measured.

The Welsh National Memorial Association, which is responsible on behalf of the counties and county boroughs of Wales for the diagnosis and treatment of tuberculosis, offered early in the present war to examine and radiograph, free of charge, all men called up for military service in the counties of Anglesey and Carnarvon, which were chosen because they have a high incidence and a high death rate from the disease. The question was later taken up with the Ministry of Labour and National Service; but unfortunately, for various reasons, satisfactory arrangements could not be made in time to include the younger age groups—i.e., the under 30's—the important categories from the point of view of tuberculosis, and the project was therefore abandoned.

The committee, under the chairmanship of Lord Horder, which the Minister of Labour appointed to advise him on problems arising from the examination of recruits by civilian medical boards, reported that:

"They had in particular explored the possibility of examining the chests of all recruits radiologically. The only way in which this could be done would, they said, be by miniature radiography, but although the adoption of this