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Radiology of uncomplicated asthma

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Hodson, Margaret E., Simon, G., and Batten, J. C. (1974). *Thorax,* **29,** 296–303. **Radiology of uncomplicated asthma.** In 22 of the 117 patients with asthma, over 15 years of age, the chest radiograph showed overinflation (O_1 pattern) and additional vascular changes in two (O_2 pattern). Neither abnormality was seen in 60 controls. Abnormal radiographs were found in 31% of patients whose asthma started before the age of 15 but in none of those in whom it started over 30 years of age. The mean age of patients with abnormal radiographs was 24·6 years, compared with 40·1 years for those with normal films. Radiographic changes bore no relation to duration of disease. In some cases the abnormality persisted; in others it was present only during the acute episode.

The appearances of the chest radiograph in children with asthma have recently been described (Simon, Connolly, Littlejohns, and McAllen, 1973). The aim of the present study is to determine the incidence of abnormal chest radiographs in patients over the age of 15 with asthma. Those with radiological shadowing of a localized nature have been excluded, e.g., pneumonia and allergic aspergillosis.

PATIENTS

We studied the chest radiographs of 117 patients admitted to Brompton Hospital with a clinical diagnosis of asthma. All patients had tests of ventilatory function performed and only those showing at least 25% variability between the highest and lowest recorded forced expiratory volume in one second (FEV_1) or peak expiratory flow rate (PEFR) were included. All these patients used daily bronchodilator drugs in order to lead a normal life and most were on long-term disodium cromoglycate, corticosteroids or ACTH.

The controls were fit members of the hospital staff, ranging in age from 15 to 65 years, and free from respiratory symptoms.

METHODS

Each patient had an FEV_1 or PEFR performed on the day of the chest radiograph in this study and relevant clinical details were recorded at the same time. The severity of asthma on the day of the radiograph was expressed as:

$$\frac{\text{PEFR or FEV}_1}{\text{Predicted PEFR or FEV}_1} \times 100$$

The best of three readings was taken on each occasion.

All the chest radiographs were reported by the same observer (G.S.) who at the time was unaware whether he was reporting the films of an asthmatic or a normal control.

RADIOGRAPHIC TECHNIQUE Each patient had a standard postero-anterior film taken at 6 ft (1·8 m) during suspended inspiration. About half the patients also had a lateral view taken.

RADIOLOGICAL ANALYSIS Measurements of diaphragm level (Lennon and Simon, 1965), lung length, lung width, and heart width were recorded. For those with a lateral film the size of the retrosternal transradiant zone was also measured. The size of the hilar vessels relative to the peripheral lung vessels was recorded.

The diaphragm level was taken as the height of the top of the right dome of the diaphragm in the mid-lung field in relation to the inferior angle of the anterior ribs. Lung length was estimated by drawing a horizontal line at the level of the tubercle of the first rib. From this line a vertical line was drawn to the top of the dome of the right diaphragm in the mid-lung field. Lung width was measured by drawing a horizontal line at the level of the right dome of the diaphragm to the internal aspect of the ribs on each side. The transverse diameter of the heart was measured as the furthest projections of the heart to the right and to the left of the mid-line added together. These measurements were performed in the manner described by Simon *et al.* (1972) (Fig. 1).

The size of the retrosternal transradiant area was measured as the distance from a point 3 cm below the angle of the sternum to the aorta (Simon, 1971).

The ratio of the size of the hilar vessels to that of the intrapulmonary vessels was recorded. This was a subjective comparison of the relative sizes of the vessels.

INTERPRETATION OF THE RADIOLOGICAL APPEARANCES The radiographs were classified into three groups:

(A) *Normal pattern* Presenting the following features:

1. diaphragm at or above the anterior rib level of 6½;
2. lung width greater than lung length;
3. heart diameter 11·5 cm or over;
4. if lateral film available, retrosternal transradiant area under 3·5 cm;
5. vessel pattern normal.

(B) *O_1 pattern* (Fig. 2a) Simple overinflation presenting two or more of the following abnormalities:

1. diaphragm below anterior rib level of 6½;
2. lung length the same or greater than lung width;
3. heart diameter less than 11·5 cm;
4. retrosternal transradiancy greater than 3·5 cm.

(C) *O_2 pattern* (Fig. 3a) Complicated overinflation similar to the O_1 pattern but, in addition, the hilar vessels are relatively large compared with the lung vessels. The change in the lung vessels is uniform (Simon *et al.*, 1973).

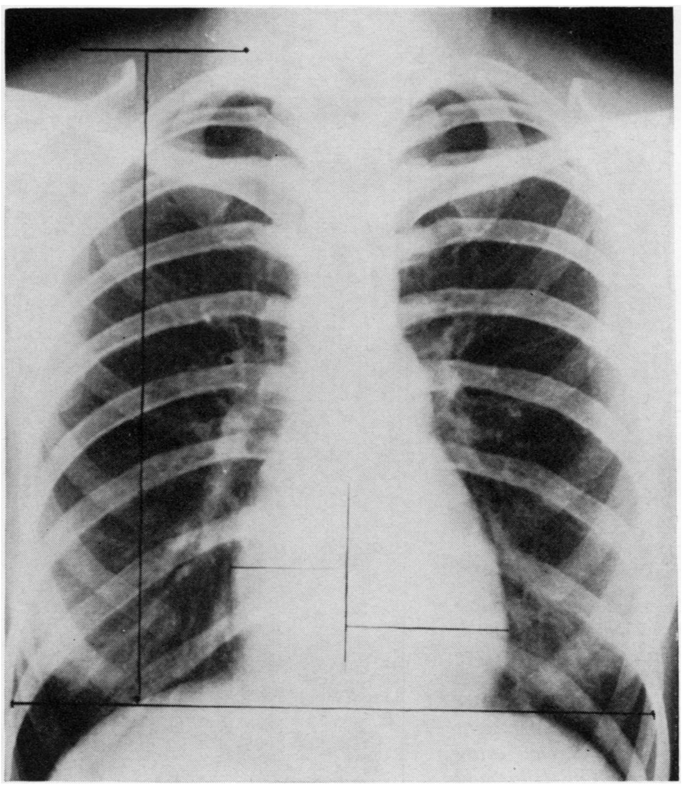
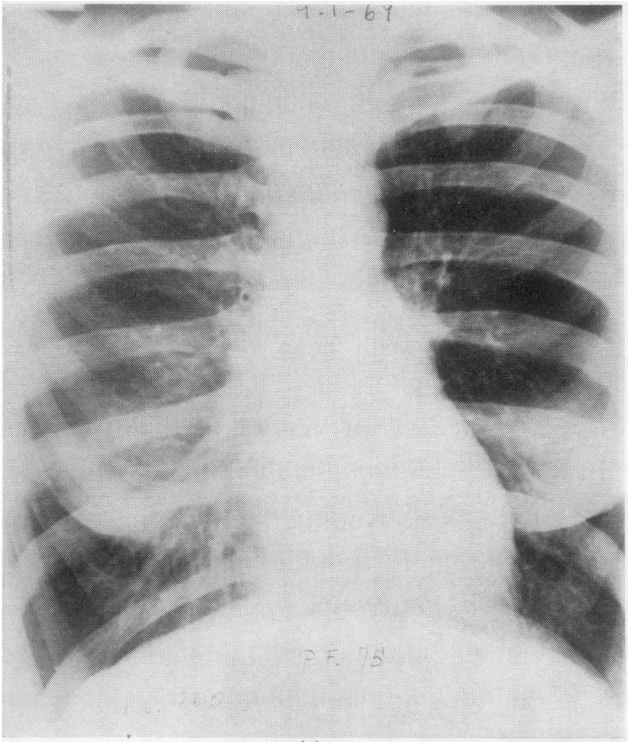


FIG. 1. *Normal radiograph showing method of measuring lung width, lung length, and transverse heart diameter.*



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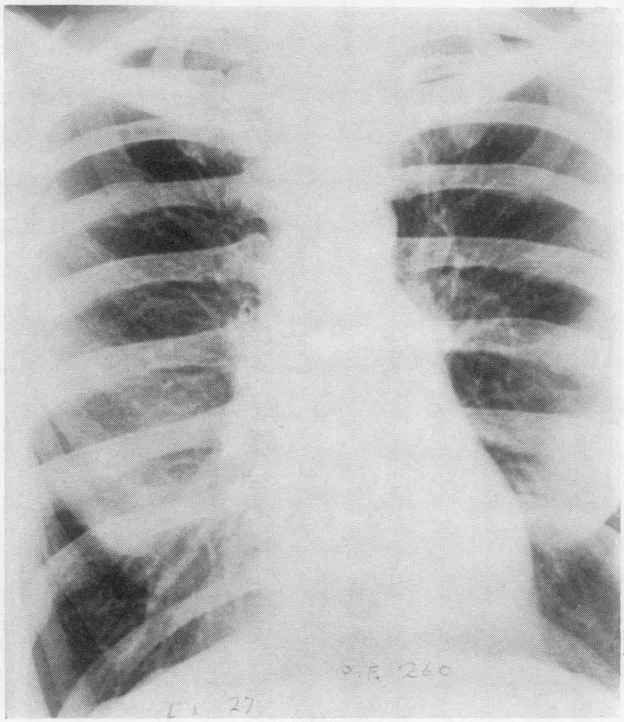
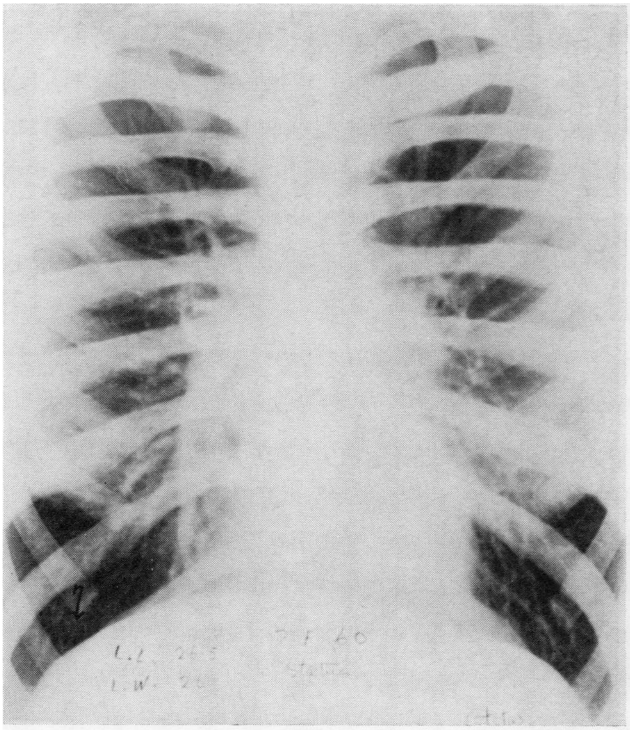


(b)

FIG. 2. *Woman aged 25 years. Asthma onset aged 2 years. (a) PEFR 75 l/min. O_1 pattern. Diaphragm at 7th rib. Heart diameter 9·5 cm. Lung length 26·5 cm. Lung width 25 cm. Hilar vessels normal. (b) PEFR 260 l/min. O_1 pattern remains. Diaphragm at 7th rib. Heart diameter 9·5 cm. Lung length 27 cm. Lung width 25 cm. Hilar and lung vessels normal.*



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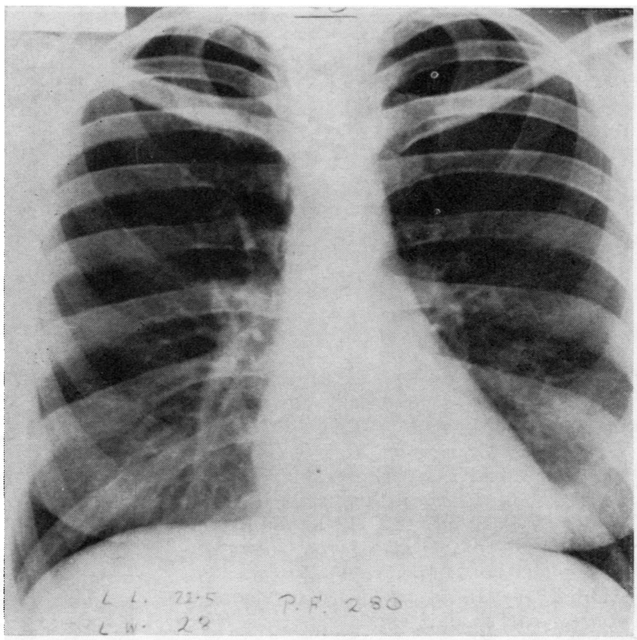
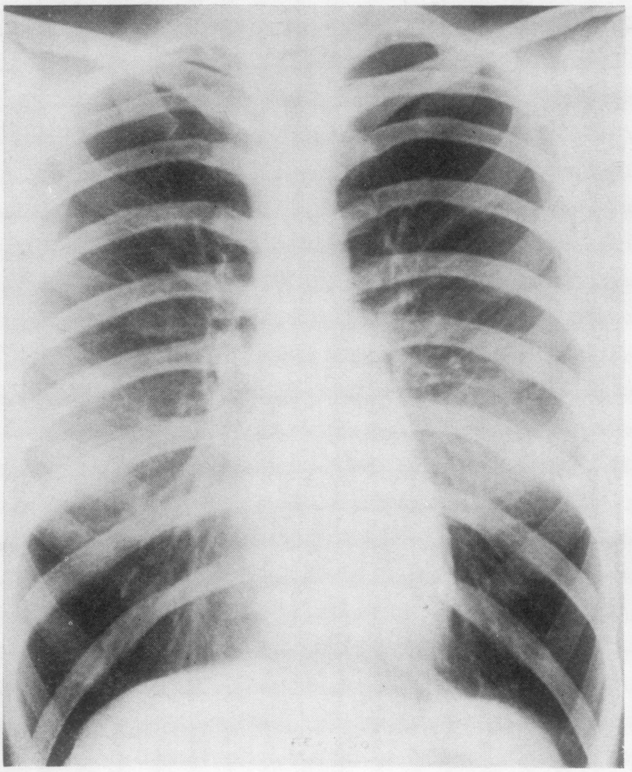


(b)

FIG. 3. *Girl aged 18 years. Asthma onset aged 2 years. (a) PEFR 60 l/min. Shows O_2 complicated overinflation. Diaphragm below 7th rib. Heart diameter 9 cm. Lung length 26·5 cm. Lung width 26 cm. Basal artery 14 mm. Peripheral vessels relatively small. (b) PEFR 280 l/min. Normal pattern. Diaphragm at 6½ rib. Heart diameter 12·5 cm. Lung length 22·5 cm. Lung width 28 cm. Hilar and lung vessels normal.*



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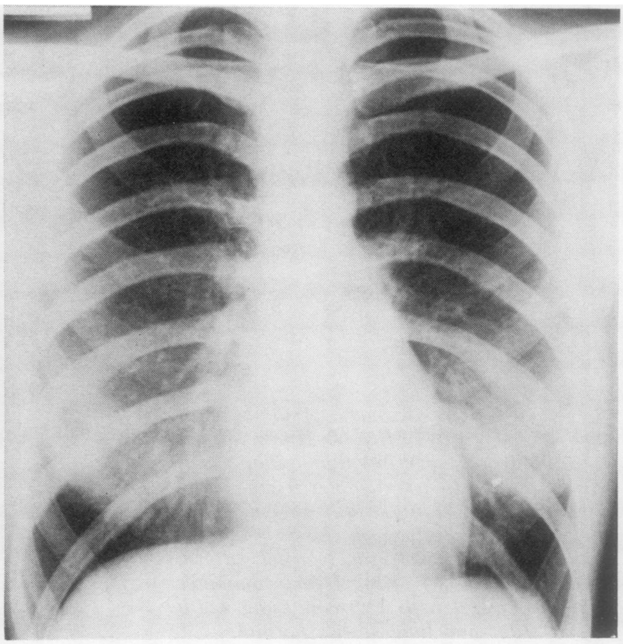

(b)

FIG. 4. *Girl aged 18 years. Asthma onset aged 2 years. (a) FEV_1 450 ml, FVC 500 ml. O_1 pattern. Diaphragm at 7th rib. Heart diameter 8 cm. Lung length 29·5 cm. Lung width 25 cm. Hilar and lung vessels normal. (b) FEV_1 3,600 ml, FVC 3,800 ml. Normal pattern. Diaphragm at $6\frac{1}{2}$ rib. Heart diameter 11·5 cm. Lung length 27 cm. Lung width 25 cm. Hilar and lung vessels normal. Retrosternal space 2 cm.*

TABLE I

	No. of Cases	Patients with: All Normal Radiographs	Some Abnormal Radiographs O_1 or O_2	Constantly Abnormal Radiographs	Abnormal Radiographs only present in Status
Controls	60	60	0	0	0
Asthmatics	117	95	22 (19%)	14 (12%)	8 (7%)

Of the 22 abnormal films (Table I), 20 were classified as O_1 and two as O_2. Some patients had abnormal radiographs when they were in an acute episode and also when they had recovered (Fig. 2b). Seven O_1 pattern radiographs and one O_2 pattern radiograph returned to normal when the acute asthmatic attack was over (Figs. 3b and 4).

These abnormal radiographs were considered in relation to the age of the patient (Table II), age of onset of the asthma (Table III), duration of the disease (Table IV), and severity of the asthma on the day the abnormal radiograph was taken (Table V). O_1 and O_2 radiographs were considered together as the number of O_2 cases was so small.

TABLE II
AGE AT TIME OF CHEST RADIOGRAPH

Age (yr)	No. of Cases	Normal Radiograph No.	Normal Radiograph %	Abnormal Radiograph No.	Abnormal Radiograph %
15–29	44	28	63·5	16	36·5
30–44	29	24	83	5	17
45+	44	43	98	1	2
Mean		40·1		24·6	

Statististically significant: $\chi^2=9\cdot3$; $0\cdot005>P>0\cdot001$.

TABLE III
AGE OF ONSET OF ASTHMA

Age (yr)	No. of Cases	Normal Radiograph No.	Normal Radiograph %	Abnormal Radiograph No.	Abnormal Radiograph %
0–14	58	40	69	18	31
15–29	25	21	84	4	16
30+	34	34	100	0	0
Mean		22·4		7·4	

Statistically significant: $\chi^2=9\cdot06$; $0\cdot005>P>0\cdot001$.

TABLE IV
DURATION OF DISEASE

Duration (yr)	No. of Cases	Normal Radiograph No.	Normal Radiograph %	Abnormal Radiograph No.	Abnormal Radiograph %
0–14	45	40	89	5	11
15–29	54	37	68	17	31·5
30+	18	18	100	0	0
Mean		18·2		19·0	

There is no significant difference between the patients with abnormal and those with normal radiographs in respect to duration of disease (Table IV).

TABLE V
SEVERITY OF ASTHMA AT TIME OF CHEST RADIOGRAPH

Ventilatory Function % predicted PEFR or FEV_1	No. of Cases	Normal Radiograph No.	Normal Radiograph %	Abnormal Radiograph No.	Abnormal Radiograph %
0–32	42	31	74	11	26
33–66	48	39	81	9	19
67–100	27	25	93	2	7
Mean		49·6		37·9	

χ^2 trend$=3\cdot73$; $P>0\cdot05$.

The difference in ventilatory function between the patients with abnormal and those with normal radiographs did not quite attain statistical significance at the 5% level (Table V).

DISCUSSION

Of 44 adult asthmatics aged 15–29 years 36·5% had abnormal chest radiographs. The abnormalities appear to be related to the age of onset of asthma but not to its duration. Thirty-one per cent of adults with onset between 0 and 14 years had abnormal radiographs but we could find no abnormal radiographs among patients whose asthma began after the age of 30. As asthmatics get older they are less liable to show this abnormal radiographic appearance (see Table II and Fig. 5).

In a recent paper (Simon *et al.*, 1973) it was shown that 27% of 218 asthmatic children had abnormal chest radiographs: 15% showed the O_1 pattern and 12% the O_2 pattern. In the present study we found 31% abnormal radiographs among adults whose asthma began before the age of 15. This resembles the incidence in children but the O_2 pattern is much less common in young adults than in children and both our O_2 radiographs were of patients with onset before 15 years.

Radiographic appearances of patients with emphysema (Reid and Millard, 1964; Simon, 1964, 1970) and primary pulmonary hypertension

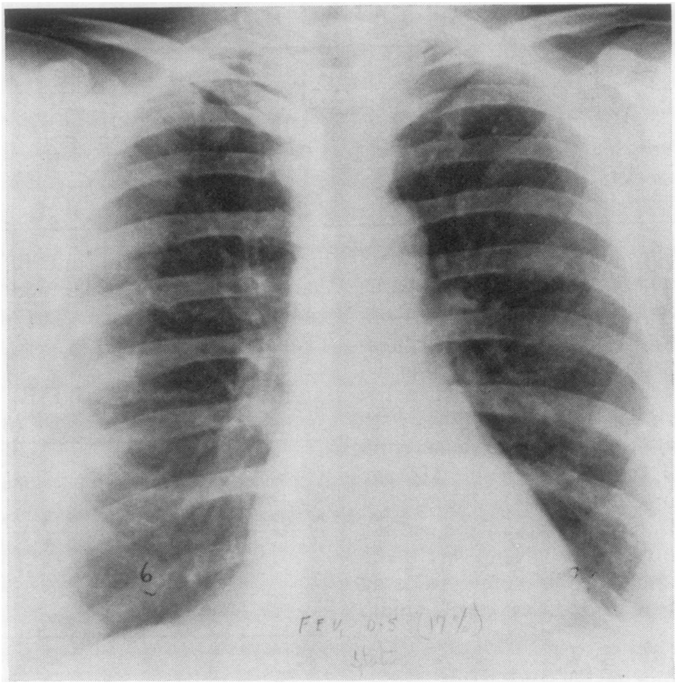

FIG. 5. *Woman aged 47 years. Asthma onset aged 38 years. FEV_1 500 ml, FVC 900 ml. Normal pattern. Diaphragm at 6½ rib. Heart diameter 12 cm. Lung length 25 cm. Lung width 25 cm. Hilar and lung vessels normal. Retrosternal space 2 cm.*

(Anderson, Reid, and Simon, 1973) may be confused with the appearances we have described here in asthmatics with an early age of onset.

Radiographs of patients with severe widespread panacinar emphysema often show a low flat diaphragm, a large retrosternal transradiant area, and a narrow vertical heart together with small lung vessels in some areas and normal or large vessels in other areas. In the asthmatics with O_2 radiographs, the vascular pattern is different in that vascular changes are uniform throughout the lungs at equal distance from the hilum.

Chest radiographs of patients with primary pulmonary hypertension show a large pulmonary artery and hilar vessels while the lung vessels appear relatively small but there is no evidence of air-trapping, so the diaphragm will appear normal and the heart shadow enlarged rather than narrow and vertical.

We conclude that there are specific radiological changes present in a proportion of asthmatics. In some, these changes are present only during the acute episode, and in others they are a constant feature. These changes appear to be related to the age of onset of the asthma and are found less frequently as the patient gets older. The reason for the radiological appearances is uncertain.

We are grateful to the physicians at the Brompton Hospital who allowed us to study their patients. We should like to thank Mrs. Ruth Tall for help with the statistics, Miss Lillian Topping for secretarial assistance, and Mr. J. Collier of the Medical Records Department.

REFERENCES

Anderson, G., Reid, L., and Simon, G. (1973). The radiographic appearances in primary and thromboembolic pulmonary hypertension. *Clinical Radiology*, **24**, 113.

Lennon, E. A. and Simon, G. (1965). The height of the diaphragm in the chest radiograph of normal adults. *British Journal of Radiology*, **38**, 937.

Reid, L. and Millard, F. J. C. (1964). Correlation between radiological diagnosis and structural lung changes in emphysema. *Clinical Radiology*, **15**, 307.

Simon, G. (1964). Radiology and emphysema. *Clinical Radiology*, **15**, 293.

—— (1970). Radiology and chronic airways obstruction. In: *Modern Trends in Diagnostic Radiology*, edited by J. W. McLaren, vol. 4, chap. 2, p. 21. Butterworths, London.

—— (1971). *Principles of Chest x-ray Diagnosis. The Retrosternal Transradiant Zone*, 3rd edition, p. 29. Butterworths, London.

——, Connolly, N., Littlejohns, D. W., and McAllen, M. (1973). Radiological abnormalities in children with asthma and their relation to the clinical findings and some respiratory function tests. *Thorax*, **28**, 115.

——, Reid, L., Tanner, J. M., Goldstein, H., and Benjamin, B. (1972). Growth of radiologically determined heart diameter, lung width, and lung length from 5–19 years, with standards for clinical use. *Archives of Diseases in Childhood*, **47**, 373.

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