BRONCHO-PULMONARY SEGMENTS OF THE LUNG AND THEIR TERMINOLOGY

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As there has been some controversy concerning the entity of the segments of the lung we will consider these before dealing with the terminology. The bronchial tree varies in each mammalian species, so we may, by referring to comparative anatomy, gain enlightenment concerning the significance of the various homologues found. The term "broncho-pulmonary segment" is applied to a branch of the stem of a lobe of a lung which has on it secondary branches with masses of lung tissues called secondary lobules. A broncho-pulmonary segment with its secondary lobules is surrounded by connective tissue derived from the visceral pleura, which sends further prolongations separating lobules and penetrating the lung tissue as interstitial connective tissue. The broncho-pulmonary segments form areas that are, in the words of Ewart (1889), who first described them, "kept in isolation as regards their air supply and form separate respiratory districts." From pathological data it is noted that infection in them may pass towards the periphery or pleura, but only gross pathology such as tuberculosis or malignancy can break through their boundaries to invade the neighbouring segments.

Willis (1676) was apparently acquainted with comparative anatomy when he drew the diagram of a lobar bronchus and its branches. It is corroborated by that of Huntington (1898) showing an embryonic mammalian

lung. This type with many lobar branches is seen in some mammals, such as the pig and the wallaroo, but one of the earliest mammals or monotremes, the platypus, has an upper lobe closely resembling that of the human. In one of the herbivora, the black buck (Fig. 1), we find a simple type of the upper-lobe stem that divides into two trunks—the subapical below and an upper one. This division can be traced in all the mammals we have dissected. On the upper or cephalad aspect of the upper trunk of the black buck may be seen two obvious homologues of the apicals. In the dog (Fig. 2) two well-marked apicals come off this trunk. Intermediate between them, but on the lateral aspect, is a well-marked axillary branch that supplies an area between the anterior, or continuation of the upper trunk, and the subapical.

FIG. 3.—Pruned cast of right upper lobe of bronchial tree of monkey.

FIG. 4.—Anterior view of cast of right upper lobe of bronchial tree of human.

The Upper Lobe

If the apicals are granted segmental status a simple classification must be accorded to the axillary. In a monkey (Fig. 3) the two apicals are fused into one segmental bronchus. The axillary is well marked, whilst the remainder of the upper trunk, taking a ventral or an anterior direction, continues on as the anterior. We show a cast of the upper lobe of a human (Fig. 4), but it is only a confirmation of the diagram of Aeby (1880), which has never been challenged. In it there is practical coequality of the axillary and the anterior.

With progress in the gradation of the mammals the upper trunk shows, first, branches that fuse and serve the apical portion of the lobe. Then the axillary segment appears. After it is given off the upper trunk continues on as the anterior segment. Thus we see that, in accordance with adaptation, branches of a lobar bronchial stem, in conformity with the diagram of Willis, may disappear or fuse with another or may become aggrandized to form a separate segment. The axillary in the higher mammals becomes progressively enlarged and serves the area between the subapical dorsally and the anterior in front. The axillary is

FIG. 1.—Lateral view of right upper lobe of cast of bronchial tree of black buck.

FIG. 2.—Lateral and slightly posterior view of cast of right upper lobe of bronchial tree of dog.

readily accessible to bronchoscopy, can be filled separately with "lipiodol," and is a recognized site of lung abscess. On a lateral view of a radiograph it overlies the bifurcation of the trachea. The attempt to incorporate it with the anterior segment ignores anatomical and clinical accuracy and does not lead to clarification.

The Lower Lobe

In the lower lobe a controversy centres round the question whether the subapical has a separate entity or should be regarded as part of the posterior basal. Starting from the proximal end in the human there are given off in succession the apical, the cardiac on the right side, the anterior basal one or two, the axillary basal, and the posterior basal, which is the continuation of the lobar stem (Fig. 5). The relative

Fig. 5.—The human right lower lobe.

position of these is constant. In various positions from below the apical to above the final major division, where the axillary basal is given off, there may be found one to three segmental orifices distributed to the subapical segment which serve the lung between the apical above and the posterior basal below. Their distribution may be medial, posterior, and lateral.

At times, particularly on the right side, the segmental orifice of a subapical may be as large as the apical segmental bronchus. It may be absent on the right side or on the left side, but it is present, however, as a substantial segment with an orifice often as large as the anterior basal in all the mammals we have dissected. Frequently on the left side in the human the proximal part of the subapical segmental bronchus is overlain by the apical above and the posterior basal below. Hence on inflation it has simply a lateral distribution.

Some contributors persist in showing the subapical of the lower lobe as part of the posterior basal—this in spite of the classical work of the first masters of bronchial anatomy, Aebly and Ewart, and the constant findings in the mammals that we have dissected. In his diagram, in which the bronchial tree is shaded to demonstrate his belief that it divides monopodially, Aebly shows the subapical definitely as a separate branch of the lower lobe of the bronchial stem, which latter eventually ends as the posterior basal. Consequently the last branch given off from the bronchial tree before it continues as the posterior basal is that of the axillary basal. A subapical branch must come off above this point to be classified as a broncho-pulmonary segment. Comparative and human anatomy definitely show this to

be true. It is not possible to see how a subapical can be considered part of the posterior basal.

Preparation of Lungs for Inflation

We once more reiterate that the most satisfactory way of demonstrating the broncho-pulmonary segments is by the Moolten (1935) method of fixing the lungs. When the lungs are fully distended *in vacuo* the air sacs are fixed in that condition. On inflation the segments may be delineated just as in a map. If a lung is simply fixed in formalin the air sacs, in contraction, are filled with fluid and debris, and inflation may cause an artificial emphysema, masking the definite boundaries. We have given up using casts for the demonstration of the segments to students, as they are not easily recognized guides to the peripheral distribution. We have found it practically impossible to get any useful results from demonstration of fresh lungs in the necropsy room: they will develop artificial emphysema on inflation when apparently just fully expanded.

Moreover, when the bronchial stem in a fresh specimen is opened, the lung collapses in its full length and recognition of the various segmental orifices is very difficult to those not well experienced. Turning over a fresh lung and holding the collapsed slippery mass in an endeavour to demonstrate the segmental delineation by inflation is worth a trial by any investigator, as it will convince him of its uselessness for accurate delineation. The Moolten apparatus is cheap and easily constructed. Specimens prepared by this method will last for years without losing their segmental delineation. The method of preparation has already been described (Hardie-Neil and Gilmour, 1946).

Terminology

The terminology of the bronchial tree was discussed at the two meetings of the Oto-laryngological Section of the Pan-Pacific Surgical Congress in Honolulu in September, 1948. The consensus of opinion was that although the entity of the axillary segment of the upper lobe was definitely accepted its name could be replaced by the term "lateral" in conformity with modern anatomical terminology. Similarly the middle lobe main divisions could be termed "lateral" and "anterior." The name "apical of the lower lobe" is a convenient and localizing one in topography. Ewart described this segment as the bronchus dorsalis, but divides it into two branches—one the apical, and the other supplying the rest of the segment. As the term "dorsal" would apply to the apical, subapical, and posterior basal segments by position, it should be discarded. The term "apical" is more localizing, and anatomically corresponds with the apical of the upper lobe. The separate entity of the subapical segment of the lower lobe was recognized, and among the basal segments the axillary basal could be termed the lateral basal in accordance with modern terminology. We now suggest the following terminology of the broncho-pulmonary segments.

Upper lobe : apical, lateral, anterior, subapical.

Middle lobe : Anterior, lateral.

Lower lobe : apical, subapical, cardiac, anterior basal, lateral basal, posterior basal.

The anatomy of the broncho-pulmonary segments, and particularly of their vascular supply, has in recent years received such detailed consideration in connexion with pulmonary segmental resection as to add to that knowledge which has been the basis of the splendid life-saving advances made in recent years in the surgery of the lung.

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Illustrations from the References may be seen in the reprint from the *New Zealand Medical Journal*, 1946, **45**, 20, a copy of which is in the B.M.A. Library.

"TRIDIONE*" IN THE TREATMENT OF EPILEPSY

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The oxazolidine diones, of which tridione is one, are structurally related both to the hydantoins and to the barbiturates. Another member of the series, dipropylloxazolidine dione, had been used some years ago (Luton *et al.*, 1941) as a hypnotic and anaesthetic, and when tridione was synthesized by Spielmann in 1944 it was originally

tried as a sedative and analgesic. However, in experimentally induced convulsions in animals it was found to be more effective as an anticonvulsant than either barbiturates or hydantoins (Everett and Richards, 1944). This observation, combined with the drug's low toxicity, recommended it for the treatment of epilepsy in man, and it has now been in clinical use for some three years.

The first report of its results was given by Lennox (1945), who noted that it was often dramatically effective in the petit-mal epilepsies, but that its expected anticonvulsant action as shown by the control of grand-mal seizures was not pronounced: on the contrary, it appeared occasionally to aggravate these. This view has been largely confirmed by subsequent workers (Richards and Perlstein, 1946; Perlstein and Andelman, 1946; Butter, 1948). Its value in psychomotor attacks also seems slight, though De Jong (1946) has claimed on rather slender evidence that, combined with other drugs, it is also effective in controlling these seizures. After two and a half years' experience of its use in 245 patients Davis and Lennox (1947) write of its "unique and almost specific effect in the control of the petit-mal epilepsies." This is a high claim for the treatment of a condition notoriously difficult to control, and may prove over-optimistic. Nevertheless all experience seems to agree that in many cases of petit mal tridione produces a striking amelioration.

Although the drug's toxicity in animal experiments was low, minor toxic effects in man are common. They were discussed in detail by Lennox (1947). He found com-

plaints of a mild photophobia or "glare" effect—so that objects appeared as with a halo when viewed in bright light—the most common. This occurred in about one-third of all patients. Acneiform, morbiliform, and urticarial rashes were also noted, though they were usually transient. Indigestion and nausea might occur. Other occasional symptoms were drowsiness, ataxia, and irritability. Similar effects were reported in this country by Butter (1948). None of these symptoms was a serious hindrance to the continued use of the drug. However, there have also been reports of more severe toxic effects. These are of two main sorts—a reduction of blood-forming activity leading either to agranulocytosis or to aplastic anaemia, and an inflammatory skin reaction which may proceed to exfoliative dermatitis.

Fatal anaemia, or granulocytopenia, has been recorded in four cases from the United States (Harrison *et al.*, 1946; Mackay and Gottstein, 1946; Lennox, 1947), but at least one of these was taking "mesantoin" as well as tridione, so that the latter may not have been the responsible agent. In this country also two cases have been reported (Braithwaite, 1948; Forster *et al.*, 1949). Similar blood dyscrasias which responded to treatment have been reported in four other cases (Greaves, 1946; Briggs and Emery, 1949); while Kerrin (1948) detailed a case in which an urticarial rash led on to a fatal exfoliative dermatitis, and Butter (1948) mentioned a similar case which recovered. Barnett *et al.* (1948) and Briggs and Emery (1949) also record two cases with a nephrotic syndrome, one of which was fatal. These reported figures—eight fatalities and a further six severe reactions—must be considered in the light of Nattrass's (1949) quoted estimate of 10,000 cases that have had tridione treatment. In this context the toxicity of the drug cannot be viewed as very high, and Briggs and Emery must have been particularly unlucky in their experience of four severe reactions in a total of ten patients treated.

Apart from the above effects, Lennox also found that in half the cases of grand mal these fits were made worse.

The drug has not been extensively used in this country, owing partly to difficulties of supply and partly to its reputation for toxicity, which seems to have been exaggerated. Only three series, of 23, 10, and 9 cases respectively (Butter, 1948; Briggs and Emery, 1949; Nattrass, 1949), have so far been recorded. In this paper the results of the treatment of 50 patients are given.

Present Investigation

Case Material.—Patients were selected in the main because other forms of treatment had failed to control or reduce their attacks. Nineteen were males and 31 females, and their ages ranged from 4 to 62 years. Treatment was continued for periods varying from 2 to 18 months. Some form of the "petit-mal triad"* was present in 46 cases: 22 had only petit-mal epilepsies; the other 24 had grand-mal attacks as well. Six of these had proved local brain lesions as the probable basis of their attacks. Of the remaining four patients, three had grand mal only, and one a unilateral tremor-rigidity syndrome due to birth injury.

Dosage.—Dosage varied from 0.3 to 1.8 g. of tridione a day, which represented one to six capsules of 0.3 g. each. With adults the initial dose was usually one capsule three

*"Tridione" is Abbott Laboratories' trade name for 3,5,5-trimethylloxazolidine-2,4-dione. It has become established in the literature as the clinical name for this chemical substance and is therefore used here.

*This nomenclature was introduced by Lennox and Gibbs, and includes "classical" petit mal, myoclonic jerks, and akinetic or inhibitory epilepsy. The grouping seems justified on both clinical and electroencephalographic grounds, and is now accepted, with qualifications, both in this country and in America.