otherwise with Wilson. Both wrote in an individual style, and what they had to impart was always important. Wilson's disciples formed a small band of votaries who would meet on a Saturday in the R.M.O.'s sitting-room to meditate upon the most puzzling clinical problems in the hospital. Wilson was a lone wolf, and if there were sections to be cut, photographs to be prepared, or recordings to be made, he would do the job himself. He gave the impression of aloofness except to those few who could penetrate his detachment.

Collier was different. Always approachable, he revelled in the admiration of the crowd. It was he who instituted the weekly clinical demonstrations which have become so famed. His technique of teaching was unconventional and even startling. He was easily seduced into tricks of hyperbole, when, as Oscar Wilde said, "facts fled before him like frightened forest things." In the lecture theatre Collier would resort to every device of display, eloquence, gesture, and emphasis. Overemphasis, too, was not despised. Collier would imitate a faulty articulation, or mimic an abnormal attitude, posture, or gait.

These were but a few of the great teachers at Queen Square. Some of them are still living. Others, prematurely deceased, are still remembered—like Adie and Riddoch, both of whom could hold an audience enrapt by their power of making simple sense out of intricate and confusing data. Listeners were shown a glimpse of the fascination which lies behind the art and science of neurology.

Sometimes it is asseverated darkly that "Queen Square is not what it used to be." First said in the 'eighties, it has been whispered consistently ever since. Doubtless it will still be murmured when the National Hospital is celebrating its second century.

The ninth annual statistical report to be published by the World Health Organization sets out in some 700 pages the demographic and health conditions of the countries of the world. It contains a number of innovations. In the first part, for instance, statistics of causes of death have been expanded. In the tables on causes of death figures have been given for deaths among young children by sex and by each year of age up to 4 years. Also a new table on the cause of infant mortality by age has been included. Among the other subjects which have been either expanded or newly introduced are cardiovascular diseases, malignant neoplasms, maternal mortality, and accidents according to the nature of injury. In the second part of the volume seasonal statistics of notifiable communicable diseases are given, with the distribution by sex and by age for certain of these diseases. The third part, which relates to statistics of health personnel, hospital establishments, and vaccinations, has also been rearranged and extended. A distinction is made between physicians proper and other practitioners entitled to provide treatment under particular and prescribed conditions in certain territories of Africa, Asia, and Oceania. The data also distinguish between private practitioners and physicians in the public health service. The number of inhabitants of each country or territory per physician is also given; the figures show vividly the still urgent need for medical personnel in certain areas of the world. Statistics of nurses and midwives have also been expanded. Statistics on vaccinations cover six major communicable diseases. An attempt has been made, for the first time, to give details of the population groups vaccinated and of the units to which the figures refer—i.e., primary vaccination or revaccination. (*Annual Epidemiological and Vital Statistics, 1956*, W.H.O., Geneva, 1959. Bilingual, French and English. H.M.S.O., P.O. Box 569, London, S.E.1, price £3.)

EXPIRATORY PRESSURES AND AIR FLOW DURING SPEECH

BY

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All wind instruments require a suitable supply of air. For speech, this air is collected under pressure in the lungs and allowed to escape through the larynx and mouth in short bursts. Roos (1936) suggested that the muscles of the larynx, soft palate, and lips are the only mechanism for controlling this outflow of air, but there is evidence that the expiratory muscles provide not a steady expiratory pressure but varying pressure pulses (Stetson, 1951). By recording tracheal pressure and the electrical activity of the diaphragm and other respiratory muscles we have confirmed Stetson's view that expiratory muscles play a large part in producing the fluctuating pressures found in speech. We have made our measurements during the speech of normal persons and of patients with complete spinal transections.

Expiration during singing and the playing of wind instruments has been studied by Floyd and Silver (1950) and Campbell (1958). Buchthal (1959) has reviewed the recent work with similar electromyographic techniques on the activity of the laryngeal muscles during speech and singing. Some of the phonetic aspects of the present research have been discussed elsewhere (Ladefoged, Draper, and Whitteridge, 1958; Draper, Ladefoged, and Whitteridge, 1957, 1959).

Methods

In order to leave the mouth entirely free, the volume-changes in the chest were measured when the subject was standing in a body plethysmograph connected to a Krogh spirometer. The plethysmograph was made by welding together two 40-gallon (182-litre) steel drums and incorporating in the lid a yoke of sponge rubber as a neck seal.

Tracheal pressures were estimated from oesophageal pressures, recorded from a small latex balloon, about 1.5 cm. in diameter and 2.5 cm. long, sealed to the end of a "polythene" catheter of 2 mm. bore. The balloon was passed through the nose until it lay about 34 cm. from the external nares. Radiological examination showed that this corresponded approximately to the level of the bifurcation of the trachea in subjects about 1.8 m. in height. The balloon in the oesophagus was filled with 2 ml. of air and, as can be seen in Fig. 1, an approximate sphere of air was held between the thin posterior membrane of the trachea and the vertebral column. Thus any changes of pressure in the trachea can be transmitted to the air in the inflated balloon. The catheter was connected to a rubber tambour, and records of the membrane excursion were obtained on a kymograph via a lever system and capillary pen. The excursions of the spirometer were recorded on the same kymograph. Howell and Peckett (1957) and Opie, Spalding, and Stott (1959) used a balloon 10 cm. long sited lower in the oesophagus to give a measure of intrapleural pressure; as discussed below, the size of the balloon and its position in the oesophagus are important.

Oesophageal and Tracheal Pressures

Experiments were carried out to check the validity of taking oesophageal pressure changes as a measure of tracheal pressure changes. First, a direct comparison was made in one subject. Tracheal pressure was recorded from a needle, 1.5-mm. bore, passed between the third and fourth tracheal rings in the midline. Pressures were measured during utterances such as counting from one to thirty or repeating "ma." Fig. 2 (open circles) shows the result. At pressures up to 12-cm. of water the correlation between oesophageal pressure and tracheal pressure during a sustained utterance of constant loudness is good.

In the second set of experiments three subjects with a balloon in the oesophagus exhaled steadily against a constant resistance. The pressure was measured by a side tube between the subject and the resistance. Fig. 2 (full circles) shows the mouth pressure and oesophageal pressure in the same subject at various levels of air-flow. The mouth pressure should be the same as that in the trachea if the air-flow is slow and there are no constrictions within the vocal tract or at the glottis. Such constrictions would be indicated by noise. As can be seen, the correlation between mouth pressure and oesophageal pressure is good.

A third series of experiments indicated that the size and position of the balloon in the oesophagus are important. Towards the end of a complete expiration, and thus beyond the expiratory excursions used in normal speech, there is frequently a tendency for oesophageal pressure to increase. At this time, in order to push out the small amount of air left in the lungs at the required pressure demanded by the loudness of the utterance (discussed below), most of the muscles of the thorax, abdomen, neck, and shoulder-girdle will be in action. Thus the balloon can now be influenced by such factors as the pushing up of the relaxed diaphragm by the greatly increased abdominal pressure and the descent of the larynx towards the thorax by the action of the neck muscles in maximum expiratory efforts. These effects were studied by recording the pressure changes during utterances with the balloon both high in the oesophagus where neck muscle influences predominate, and low in the oesophagus where abdominal and other influences should exert effects.

Fig. 1 shows the pressure changes seen when the balloon is in different positions in the oesophagus during an utterance such as counting, in a conversational voice, from one to thirty or reiterating "ma" for as long as a controlled loudness is possible. At each level the initial pressure changes are much the same, but as expiration proceeds the records from both the upper and the lower oesophagus show systematic increases which do not appear in the records from the central oesophagus. These increases in pressure can also be affected by movements such as bearing down in expiration or altering the quality of the voice by pulling the larynx up and down with the muscles of the neck.

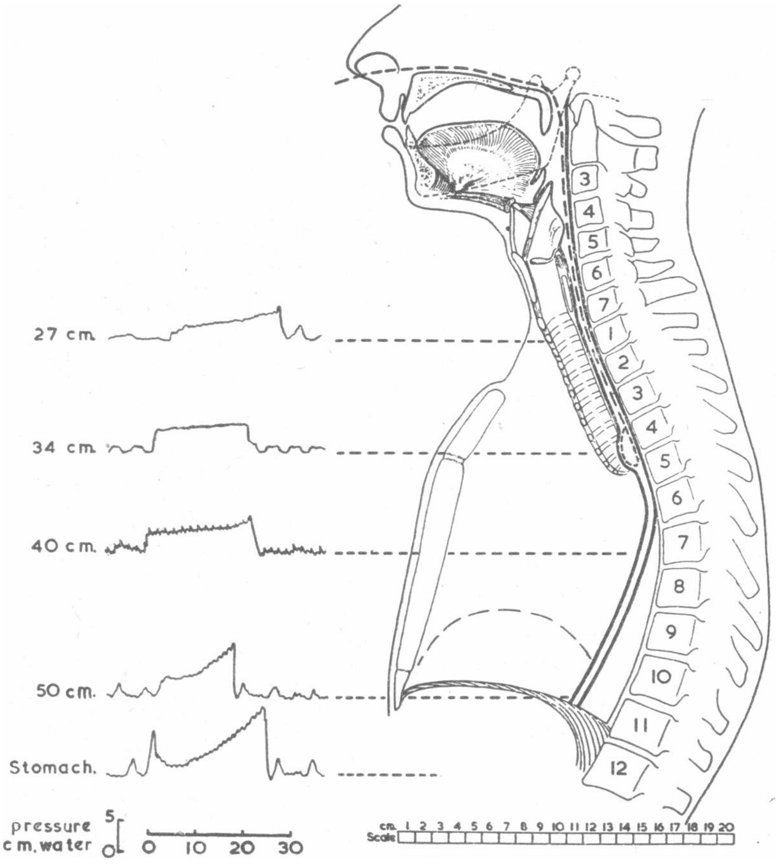

Fig. 1.—A diagrammatic scale-drawing to show the position of the balloon in the oesophagus when studying tracheal pressure changes. The bulge of the anterior aspect of the balloon into the thin posterior tracheal membrane has been slightly exaggerated for clarity. The broken line above the diaphragm represents the possible extreme position of the lateral parts of the diaphragm in deep expiration. At the side of the drawing are placed the pressure records obtained during a standard utterance at the levels 27, 34, 40, and 50 cm. from the external nares, and from the stomach (60 cm. down). The 34-cm. level gives the best indication of tracheal pressure changes and, as can be seen, is least influenced by other pressure changes, which become particularly prominent towards the end of a long utterance. (Time scale in seconds.)

These three sets of experiments show that the pressure changes in the trachea can be assessed with reasonable accuracy from measurements of pressure changes in a small balloon in the oesophagus.

The peristaltic contractions of the oesophagus are quite characteristic and easily distinguished from the changes caused by speech. There are also on occasion much slower changes in oesophageal tone which, unless measured against a constant baseline, may be overlooked, but as the pressure changes in speech in these experiments were large and rapid compared with these slow changes little difficulty in interpretation was encountered.

Electromyographic recordings were obtained using surface or concentric needle electrodes and the conventional cathode-ray oscillographic technique. Two double-beam cathode-ray tubes were used so that four events could be photographed simultaneously. The surface electrodes consisted of small silver disks 0.8 cm. in diameter. Records obtained from surface electrodes rarely have a simple interpretation because of the complex nature of the muscle layers about the thorax and abdomen. They were useful over the rectus abdominis and over the scapular triangle, where the external intercostals can be studied. For recording the activity of the diaphragmatic crura, modified surface electrodes consisting of three circles of silver wire 0.5 cm. apart, one of which was earthed, wrapped around the end of a polythene catheter, were most satisfactory. This catheter was passed down the oesophagus until it rested between the crura of the diaphragm.

The greatest electrical activity occurred at about 50 cm. ± 1 cm. down from the external nares, in a subject 1.8 m. in height. The concentric needle electrodes used consisted of either a single insulated wire sealed in a varnished hypodermic needle or two 50-μ insulated silver wires sealed in a hypodermic needle with the tip of the needle ground down under binocular vision to expose the silver wires.

Two microphones were placed about 25 cm. in front of the subject's mouth. The output of one was fed into a high-quality tape recorder and a meter for measuring average signal strength. The output of the other was suitably amplified and displayed on one beam of the four-channel cathode-ray oscilloscope. Two channels were used for the electromyograms and the other for either pressure or volume changes.

Speech and Tracheal Pressure

Conversational speech with its hesitations and stresses is not easily analysed. As a standard utterance, a repetition of the single syllable "ma" at about 2 per sec. or counting up to thirty proved to be quite satisfactory. Fig. 3 shows the result of asking a resting subject to take a breath and to count for as long as possible at a conversational level of loudness. During quiet respiration the changes in oesophageal pressure are very small. When the subject breathes in more deeply the oesophageal pressure drops slightly, and when he begins to talk the pressure rises sharply to 3.5 cm. of water and the mean pressure remains at this level. At the same time the steady change in thoracic volume indicates that the mean flow of air through the upper air passages is also constant. At the end of the utterance, which is close to the limit of expiratory effort, the pressure drops and reverts to the resting pattern.

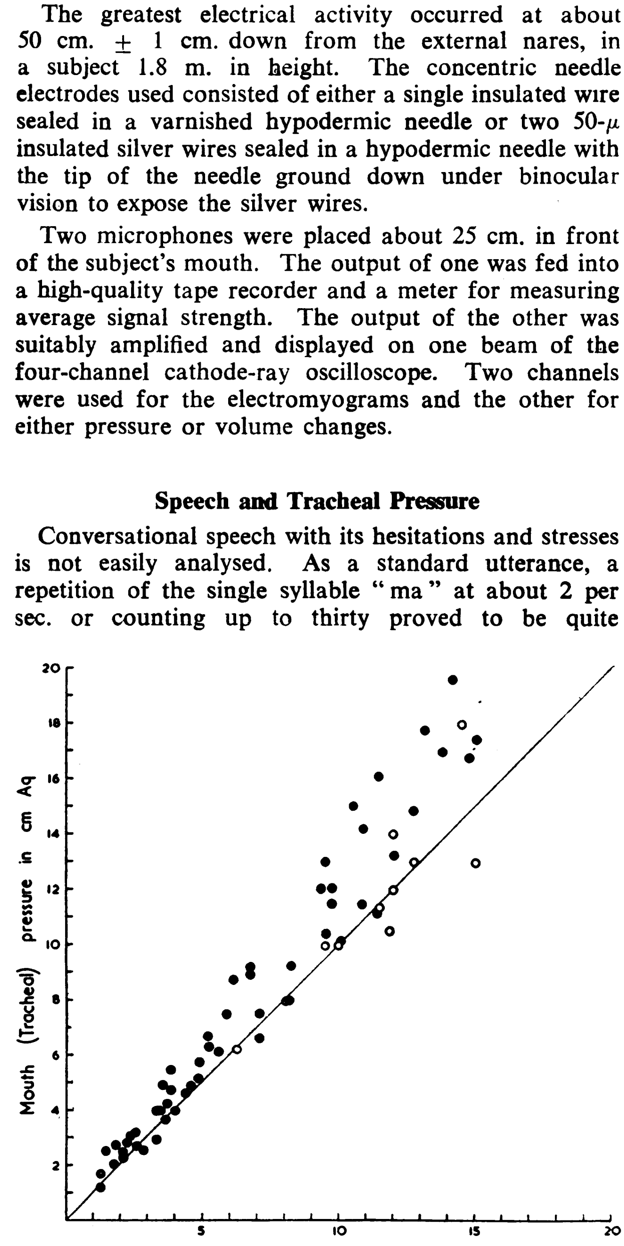

FIG. 2.—A plot of oesophageal pressure against simultaneously measured tracheal pressure (open circles) or mouth pressure (full circles). The measurements were made during sustained speech in the tracheal puncture experiment or during sustained exhalation against a constant resistance in the mouth pressure experiments. The full line is drawn at 45 degrees.

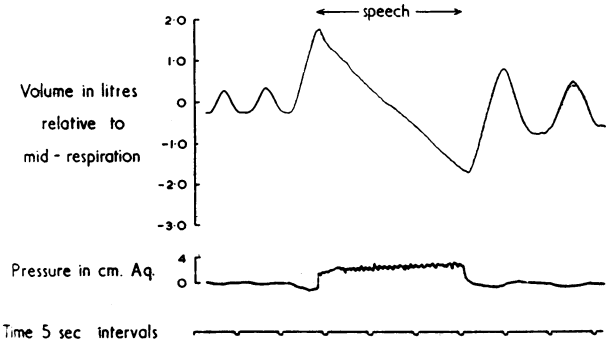

FIG. 3.—A simultaneous record of lung volume changes (top) measured from a body plethysmograph and tracheal pressure changes measured from an oesophageal balloon during normal breathing followed by a prolonged conversational utterance after a moderately deep breath. The small fluctuations in the mean pressure correspond to the stresses in the utterance, which was counting from one to 30.

If the loudness is increased, then the same pattern of changes is seen with a corresponding increase of airflow and mean oesophageal pressure. It was not possible to measure the loudness in absolute terms in these experiments, which were conducted in an ordinary reverberant room. However, the intensity meter connected to one of the microphones showed that a change of 2 db in the intensity of the vowel in "ma" could be correlated with a change of the order of 1 cm. of water in the mean pressure level over the range of 40 db change and 20 cm. of water pressure in the trachea. Quiet talking usually occurred with a pressure of 4–6 cm. of water, and parade-ground shouting 40 db up in intensity level needed pressures between 20 and 30 cm. of water.

From these results it is clear that the louder the speech the higher the pressure in the trachea. The flow of air resulting depends on the setting of the vocal apparatus. If the loudness is kept constant, then the mean pressure in the trachea will also remain constant, despite the fact that the thoracic volume can change from maximum inspiration to maximum expiration. Superimposed on the mean pressure in the trachea, small fluctuations in pressure corresponding to stressed syllables in the utterance can often be seen. When a pressure-recording system with a faster time-constant is used (Ladefoged *et al.*, 1958), these smaller fluctuations become more obvious.

Muscular Control of Mean Tracheal Pressure

The next part of the investigation concerned itself with the development and maintenance of the background pressure in the trachea and any muscular control of the superimposed fluctuations of pressure associated with stresses in speech. In three subjects simultaneous measurements were made of mid-oesophageal pressure, lung-volume changes, and electrical activity in two muscles concerned with respiration while uttering " ma " at different loudnesses and with lung-volume changes of about 4 litres. The external and internal intercostals, the diaphragm, the lattissimus dorsi, the rectus abdominis, and the external oblique were studied in pairs in each subject. The most convenient site for inserting the concentric needle electrodes for the internal intercostals was the fifth intercostal space 7.5 cm. posterior to the mid-axillary line. The needle can also be sited between the internal and external intercostals at this point. Sometimes it was desirable to have the electrode sampling unequivocally the activity of one intercostal muscle. The fourth interspace 7.5 cm. from the mid-sternum was found to be a suitable site for the internal intercostal alone as the external intercostals are deficient anteriorly. Likewise, the internal intercostals are deficient posteriorly, and in the region of the scapular triangle records were obtained which were undoubtedly from the external intercostals.

The results of such a study from one subject are set out in Fig. 4. To avoid confusion the activity of the external and internal intercostals has been set out in Fig. 4 I and the corresponding activity in the latissimus dorsi, rectus abdominis, and external oblique in Fig. 4 II. The symbols—that is, filled or open circle, and cross—indicate the point where, at the corresponding lung volume, the muscle activity stopped or started at the particular loudness under investigation. The dotted or full line indicates that the muscle was active. Thus in Fig. 4, consider an utterance at conversational loudness which would correspond to a pressure of 4 cm. of water. At the top of inspiration (2 litres above mid-respiration in these experiments) and the beginning of the speech, the inspiratory external intercostals are active and are needed to offset the passive recoil of the thorax and lungs. They stay active until the lung volume has declined to about 400 ml. above mid-respiration, when units start to drop out and units of the internal intercostal start to come in ; at about 100 ml. above mid-respiration all external intercostal activity has ceased and the expiratory internal intercostal activity has taken over. At lower lung volumes the passive recoil is not sufficient alone to sustain the pressure of the air in the trachea at a constant level, and so expiratory muscles must become increasingly active as the lung volume decreases. Transferring to Fig. 4 II at the same pressure (4 cm. of water) it can be seen that as expiration deepens more muscle groups come in, latissimus dorsi appearing at about 1,300 ml. below mid-respiration.

If a much louder utterance is studied, say at 10 cm. of water, the external intercostals cease activity at about 1,200 ml. above mid-respiration and the expiratory groups of muscles come in at correspondingly earlier points in expiration. The point at which inspiratory muscles become silent while the expiratory muscles come into action at a given sustained positive tracheal pressure should occur on the relaxation curve. The two diagonal lines on the figures represent the passive recoil pressure range that might be expected at each lung volume, and are taken from the data of Howell and Peckett (1957). The top line corresponds to the average thoracic pressure–volume relationship in conscious supine subjects and the lower line corresponds to the relationship in the same group of anaesthetized and curarized subjects. The lung compliance corresponding to the top line is 0.15 l./cm. of water, and corresponds to the lower limit given for males, average age 28 years, in the tabulations of Dittmer and Grebe (1958). The

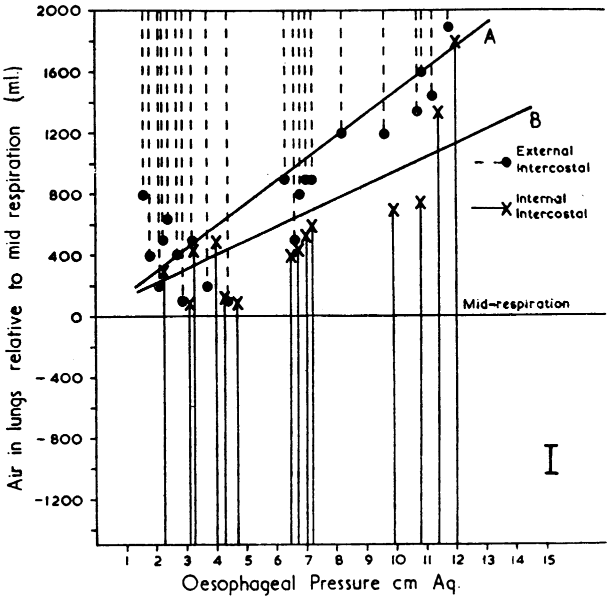

FIG. 4 I

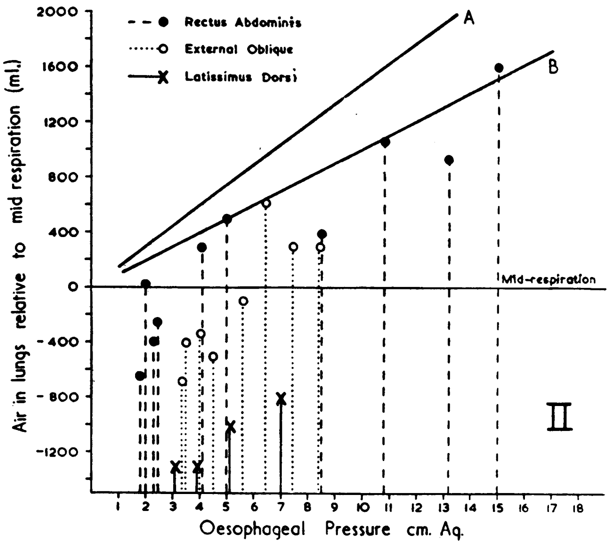

FIG. 4 II

FIG. 4 I and II.—Diagrams to show the changing muscular forces necessary to expel air from the lungs at different sustained pressures. 4 I is concerned with the internal and external intercostal muscles. 4 II shows separately, for convenience, the corresponding activity in the rectus abdominis, external oblique, and latissimus dorsi. In 4 I, at a conversational level of 4 cm. of water in the trachea, the external intercostal muscles are active until the chest volume is just above mid-respiration. Below this, with some overlap, the internal intercostals come into operation. In 4 II, as the chest volume decreases, the rectus abdominis, then the external oblique, and, finally, at the end of full expiration, the latissimus dorsi come into operation. At higher pressures the external intercostal muscles go out of action earlier and the other muscles come in earlier. The diagonal lines A and B are possible upper and lower limits of the relaxation pressure curve derived from Howell and Peckett (1957).

equivalent compliance of the lower line is 0.10 l./cm. of water and should represent the lower limit of compliance.

Howell and Peckett suggest that one of the possible factors for the reduction in the compliance in unconscious paralysed subjects is the absence of inspiratory muscle activity, which is very difficult to suppress by voluntary efforts when lung compliances are measured in conscious subjects. Thus it can reasonably be argued that the true compliance should lie between these two lines. Thoracic compliances were not measured in the subjects of these experiments and hence not too much weight can be placed on the derived lines of Fig. 4. However, it is clear that the cross-over between inspiratory and expiratory muscle groups at different pressures does occur along a line which gives a relaxation curve of the general slope to be expected from the data in the literature (see Dittmer and Grebe, 1958).

The observations in Fig. 4 are sufficient to give a clear idea of the general pattern. The points indicating the end of activity are not particularly consistent, apart from a general trend to come in or go out earlier as the pressure required rises in the trachea. It would need many hundreds of observations to define more clearly the pressure-volume range of each muscle group. Each point represents the cessation of activity in a few motor units, and if it falls short of the expected line it is probably because these particular units are recruited rather late in the general development of tension and hence go out of activity earlier.

The diaphragmatic activity is best considered separately because of its interest in connexion with beliefs concerning breath control, particularly in singing (see Luchsinger, 1953). In 9 out of 11 subjects the diaphragmatic activity ceased during the first two or three seconds of an utterance after a maximal inspiration, and thus played no part in the subsequent control of the thoracic volume. However, in two subjects the diaphragm did not relax for a considerable time, and there was increased activity of the expiratory muscles apparently to overcome the prolonged inspiratory activity. The diaphragmatic activity in expiration is what would be expected in the *Atemstütze* or "breath hold" concept of the mechanism for expiratory control (see Draper *et al.*, 1959). The present studies, so far as they go, indicate that in most people expiratory control during speech is primarily a matter of co-ordination between the external and internal intercostal muscles.

Speech in Paraplegic Subjects

The investigations described above show that the production of sustained speech depends upon the ability to produce a sustained positive pressure in the trachea by means of the activity of thoracic and abdominal muscles. Speech should be disturbed if these muscles are paralysed, so a number of paraplegics with lesions in the cord at levels ranging from C 4 to T 12 were examined. Because of their reduced vital capacity, patients with lesions between C 4 and C 8 could not produce long sentences. Most of them had only a limited amount of control of the pressure of the air in the lungs, and could not produce any increase in pressure when near the lower limit of their vital capacity. Consequently they were unable to stress the last word in a sentence such as "Please pass the *salt*." But they could all vary the degree of stress on the first few words of an utterance. Many of them had noticed their inability to "talk loudly" since their accident; and most of them had found that it was easier to talk when lying down.

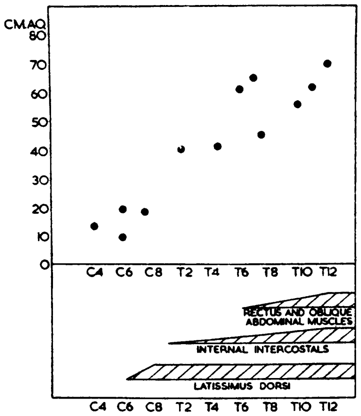

FIG. 5.—Observations of the maximum pressures which were maintained by paraplegic subjects with lesions at different levels. The damage to the principal expiratory muscles can be assessed in each subject from the segmental innervation diagram in the lower part of the figure.

The maximum pressures which can be maintained by paraplegics with lesions at different levels are indicative of the forces which various muscles can contribute to an expiratory effort. These pressures were recorded, and are as shown in Fig. 5.

It was striking that patients with lesions at C 8 to T 1 used the latissimus dorsi largely for talking. It could easily be felt contracting to produce stressed syllables. In patients with lesions at C 6 and C 5 this muscle was paralysed, but some expiratory pressure could be produced by adducting the scapulae with the levators and perhaps with the rhomboids.

Internal Intercostal Activity and Particulate Speech

Perhaps the most surprising observations made in this study were those concerning the activity of the internal intercostal muscles during speech and the correlation of this activity with the small changes in pressure seen superimposed on the mean tracheal pressure and the correspondence of these changes in turn with the production of certain elements of the utterance or the stresses in the utterance (Ladefoged *et al.*, 1958; Draper *et al.*, 1959). During quiet respiration there was usually no activity in the internal intercostals, but as soon as any utterance was attempted the internal intercostal muscles became active. Fig. 6, first utterance, shows that about 50 msec. before the speech begins—that is, before any detectable activity is seen in the microphone record—the motor units start activity, and this activity can be seen to fluctuate during the phrase, "He wanted to be an elevator operator." Study of short sentences such as this has shown a relationship between the action potential frequency and the stressed syllables or those elements, such as "h," which need more air flow. These correlations are not exact, probably because the motor-unit sample is too small to be fully representative. There are in the records of Fig. 6 perhaps up to 20 motor units active during the phrase. The fact that such a small sample taken from the whole chest wall can reflect to any degree the rapid changes occurring in speech is indicative that the intercostal muscles must be comparable in speed of action with the small muscles of the hand.

Fig. 6 shows how, as the phrase is repeated with the same breath, the total number of action potentials during the phrase increases as more and more energy

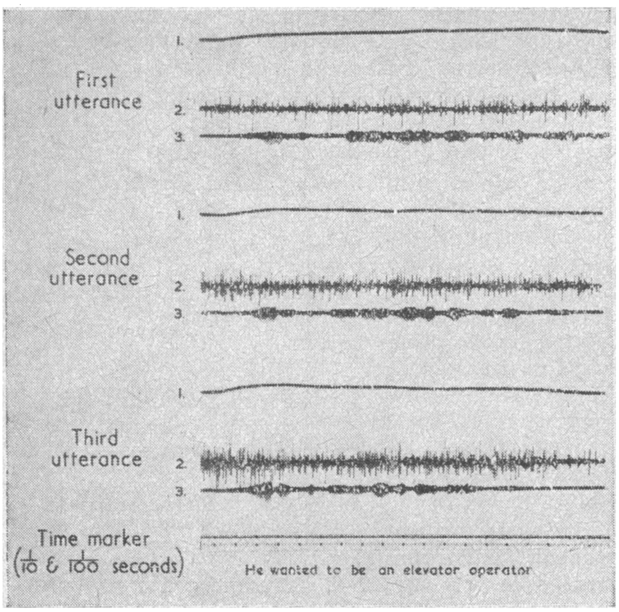

FIG. 6.—Activity recorded from the internal intercostal muscles during one breath and three successive repetitions of the phrase, "He wanted to be an elevator operator." The overall muscular activity increases as the chest volume decreases. Close examination of the records shows that in each utterance there is a consistent pulsing action of the muscle before stresses in the sentence. Line 1, oesophageal pressure; line 2, electromyogram of the internal intercostal muscle; line 3, microphone record.

must be expended to push out the air at constant mean pressure. The relationship between the moments of comparatively high muscular activity and certain elements of the utterance is preserved.

The activity of the internal intercostals during speech was consistently observed not only many times in the same subject but in all six subjects in whom electromyographic studies were carried out with concentric needle electrodes. This rapid variation of muscle activity was, with one exception, not observed in the other muscles examined in Fig. 4. Thus in this respect they are accessory muscles primarily concerned with the cruder aspects of the mean pressure level in the trachea. Pulsing can be achieved by these muscles if the speech effort is vigorous enough. Fig. 4 shows that at quiet conversational pressures (about 4 cm. of water) taking place within the normal tidal air (± 250 ml.) the only expiratory muscle operating is the internal intercostal. The rectus abdominis can come in early, but, contrary to phonetic belief, it does not appear to be concerned intimately with the production of the elements of speech ; rather, its function would seem to be fixation of the anterior abdominal wall, usually coming in earlier than the external oblique. Thus the "squeeze" of the internal intercostals operates from the fixed first rib across each rib and then via the abdominal muscles to the pubic symphysis, Poupart's ligament, and crest of the ilium.

The exception mentioned earlier is in the action of the external intercostals. In one subject out of the three studied, activity was observed after the stressed syllable, thus checking the expulsion of air by the elastic recoil of the thorax. This checking action was seen only in utterances with lung volumes well above mid-respiration (Fig. 4 I).

The fact that bursts of action potentials are consistently observed in the internal intercostal muscles before stressed and certain other syllables—for example, those beginning with "h"—prompted a few observations on the general timing of this complicated mechanism. Simultaneous records were obtained of the activity of the internal intercostals, the oesophageal pressure, and the sound waves of a subject who was instructed to respond by saying "ma" as quickly as possible after hearing a stimulus such as a tap with a coin on the microphone. A typical record is reproduced in Fig. 7. The overall reaction-time varied considerably, as is to be expected in an unrehearsed subject. The shortest time from the start of the stimulus to the start of the internal intercostal activity was 140 msec. ; the longest record was 320 msec. However, the interval between the beginning of internal intercostal muscle activity and the first sound was comparatively constant at 48 msec. for "ma," "me" and "nine" (S.D. 8 ; n=9). At 20–40 msec. after the muscle activity started the oesophageal pressure began to increase. Some further observations were made where the subject had simply to decide what utterance was required. He was then asked to repeat the number called. The time from the action potentials in the internal intercostals to the first sound was still constant at about 50 msec.

Wind Instruments

The pressures required for playing musical instruments have been reported previously (Roos, 1936). Sharpey-Schafer's and our results agree closely with the figures given (see Faulkner and Sharpey-Schafer, 1959). In flute-playing the problem in soft passages is to keep a steady pressure of 0.5 cm. of water—much lower than is usual in speech. If considerable inspiratory volume is taken and held, the problem is to oppose steadily the considerable recoil pressure exerted by the inflated chest. In oboe-playing, and particularly in trumpet-playing, the problem is to obtain the very high sustained intrathoracic pressures of up to 100 or even 160 mm. Hg. In Professor Faulkner, of Santa Barbara, who kindly acted as a subject, considerable activity was observed in the abdominal muscles, especially the external obliques, as soon as he began to play. Some activity was seen even during the inspiration preceding the playing.

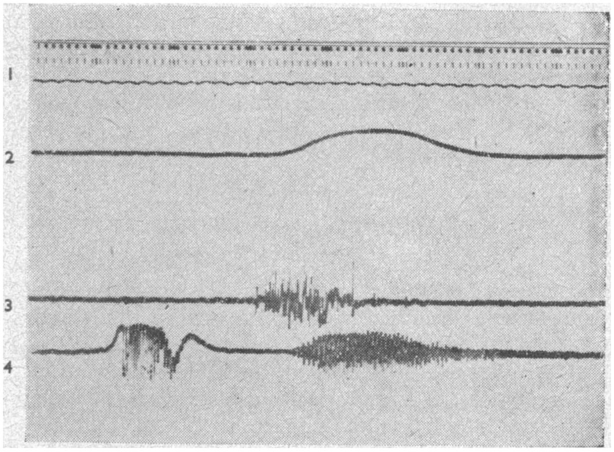

FIG. 7.—Simultaneous records of the sound waves of a stimulus and utterance (line 4), the activity in an internal intercostal muscle (line 3), and the oesophageal (i.e., tracheal) pressure change (line 2) in a subject instructed to say "mâ" on hearing a tap on the microphone. The muscular activity precedes the beginning of the pressure wave by about 30 msec. and the sound waves by about 50 msec. Line 1 gives time marks in hundredths and tenths of seconds.

Diaphragmatic activity dropped to a minimum during the first second of expiration. With loud trumpet-playing, the recorded activity with diaphragmatic leads slowly increased again towards the end of expiration, but activity was always much less than that recorded during inspiration.

In view of the anatomical relationships of the oesophagus as it passes through the diaphragm, it seems unlikely that these action potentials can be ascribed to any other muscles. The activity in the external obliques increased steadily throughout expiration. The late re-entry of diaphragmatic activity in these extreme conditions is puzzling and no adequate explanation is available. This combination of contraction of abdominal muscles and diaphragm was also seen during efforts at "bearing down."

Summary

Methods are described for estimating the tracheal pressure during speech and of recording activity in the diaphragm and a variety of thoracic and abdominal muscles.

During a steady level of loudness of speech the mean tracheal pressure is kept remarkably steady. The pressure needed varies from 2 cm. of water for very quiet speech to 30 cm. for parade-ground shouting.

To attain a steady level of 2 cm. of water throughout an expiration the inspiratory muscles—the external intercostals—at first oppose the relaxation pressure (there is usually a short period when all muscles are inactive and the relaxation pressure acts alone); then expiratory muscles, beginning with the internal intercostals and later involving other muscles, such as the rectus abdominis, reinforce the diminishing relaxation pressure.

In paraplegics the maximal expiratory pressure that can be exerted is lower the higher the level of transection between T 12 and C 6.

The shortest reaction time when a subject was instructed to say "ma" as soon as possible after a sound was 140 msec. to the start of internal intercostal muscle activity. The first sound started consistently about 50 msec. later.

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MAATERNAL HEALTH AND MONGOLISM

BY

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The genetical basis of mongolism has been established by the recent discovery of an extra chromosome in the cells of affected individuals. The cause of this abnormality, however, remains unknown, but there are reports of associated effects, often connected with maternal status, which may be of aetiological significance.

For this reason much attention has been paid to maternal health and, in particular, to endocrinological, gynaecological, and obstetric abnormalities. With respect to endocrinological changes, early reports were for the most part contradictory and were not supported by objective findings. Thus Dollinger (1921), Myers (1938), and Benda (1949) had reported a high incidence of thyroid abnormalities in the mothers of mongols, but this was not confirmed by Øster (1953).

No objective findings were reported until Ek (1959) and Ek and Jensen (1959) published the results of their investigations into thyroid and adrenocortical function in the mothers of mongols. Ek investigated 41 mothers of mongols and reported that their serum protein-bound iodine (P.B.I.) was significantly raised (mean value 7.1 μg./100 ml.) compared with that of a control group (mean value 5.9 μg./100 ml.). Ek and Jensen also studied the corticoid output in the urine of 20 of these mothers, and found that, though the 17-ketosteroids and 17-ketogenic steroids were normal, certain fractions containing dehydroepiandrosterone and an ether-extractable tetrazolium-salt-reducing ketocorticoid were double the value found in a control group.

Ek also reported that 20 of the 41 patients had marked psychoneurotic symptoms and that the increase in P.B.I. was most marked in these women. This is in keeping with observations of Benda (1949) and Øster (1953, 1956) that there is an increased incidence of nervousness and neurosis in the mothers of mongols.

The present study was designed primarily to investigate further these factors, which may be of possible aetiological significance in mongolism.

The Investigation

The present series consists of 55 mothers of mongols. Their ages ranged from 28 to 61, with a mean of 44.1 years. The mean number of years between the birth of the mongol and the interview in the present investigation was 10.6 years. In each case every effort was made to obtain accurate information from the mother regarding past events, but it was fully realized that distortion of memory occurs with the passage of time, and this is especially so in connexion with the circumstances surrounding the birth of a defective child. None of the mothers had any family history of consanguinity among their forebears. All had borne only one mongol, except one who had borne two mongol daughters.