disease allows of no more radical alternative the operative risk must be accepted, for success in obtaining a satisfactory collapse carries with it some prospect of improvement in the contralateral disease. The abandonment of the pneumothorax without thoracoscopy and the maintenance of an unsatisfactory collapse are both bad practice.

Summary and Conclusions

The state of 200 cases of unilateral internal pneumolysis 5 years after operation is reported.

Of these cases 2 were lost sight of in this period. 133 (66.5%) survived 5 years. 71 (86.5%) of those cases in which a satisfactory collapse was obtained by operation survived 5 years, and 56 of these were well and working after 6 years: none of them had a satisfactory collapse before operation.

A satisfactory collapse on one side seems to have greatly improved the prospect of survival in cases with bilateral cavitation.

The persistence of positive sputum 3 months after division of adhesions indicates a poor prognosis. On the other hand, a negative sputum improves the outlook in the "incomplete" and "ineffective" collapse groups.

Tuberculous empyema, especially when secondary infection is present, is a serious complication, but it accounted for only 18% of the deaths in 5 years.

If artificial pneumothorax is employed the aim should be to obtain the most complete collapse possible by the use of internal pneumolysis.

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HIGH-TONE DEAFNESS IN SCHOOL-CHILDREN SIMULATING MENTAL DEFECT

BY

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Some years ago, after several examinations, I certified as mentally defective a girl aged 9 who had been referred to me in school as a case of backwardness associated with speech so rudimentary that the child was practically dumb. She was said to hear normally. She came when she was called and she had every appearance of understanding simple orders and requests. I verified this by several rough tests such as calling her name loudly, ringing bells, beating an enamel bowl, clapping my hands, etc., behind her back at distances ranging from one to ten feet. She never failed to turn immediately with a bright eager smile. Her elder sister had been a certified defective and had attended a special school. There had been no question of deafness in the older girl's case: the diagnosis appeared only too obvious. In the special school, however, with its better opportunities for individual observation and teaching, it was soon apparent that the child's general behaviour, muscular control, and handwork were vastly superior to that of her classmates, and the possibility of some unusual form of deafness was considered. She was sent to the Department of Education for the Deaf at Manchester University, where Dr. and Mrs. Ewing were conducting their first work in audiometry. The audiogram at once showed that the child possessed only "islands of hearing." She was transferred to the Royal School for the Deaf at Old Trafford, where, since her intelligence was actually of a high order, she responded most satisfactorily to Dr. and Mrs. Ewing's (1938) methods of combined lip-reading and hearing-aid methods.

This case, and a somewhat similar one, prompted me to investigate the whole subject of speech and language from the physical rather than the psychological point of view, and I

was granted the privilege of studying phonetics and audiometry in Mrs. Ewing's department at the University. As my ear became more sensitive to fine distinctions in sound, and my eyes more observant to detect slight differences in the articulatory movements of the tongue and lips, I began to distinguish innumerable sound substitutions and omissions of which I had hitherto been more or less oblivious. It was soon obvious—as every speech therapist knows—that these substitutions and omissions followed definite patterns. My problem was to discover, if possible, why the same patterns kept recurring. It occurred to me that some sort of classification according to sex, age, and intelligence would be useful for the purposes of the survey. I decided to exclude cases of "baby speech" under 5 years of age. Over a period of three years I examined the speech of some thousands of elementary-school children between the ages of 5 and 14 in London, Manchester, and Cornwall. These places were chosen because the local accents differ very widely and because facilities happened to be available to me. The investigation was later widened to include some hundreds of secondary-school children of corresponding age groups: 100 certified mental defectives; 100 blind children; and finally 100 children known, from pure-tone audiometric examination, to be suffering from impaired hearing. Examination of this last group was made possible through the kindness of Dr. J. L. Burn, the medical officer of health for Salford, who had conducted a hearing survey of his entire school population, using first a group pure-tone test and then giving an individual pure-tone test to those who failed to reach the normal level in the first test. The detailed findings of the survey are too lengthy and complicated to give here, but it gradually became apparent that defects of speech are most commonly found in mentally retarded children and in children with impaired hearing; and that, although the patterns of speech defect were very similar in the two groups, certain sound substitutions and omissions were more often associated with impaired hearing, and certain others with mental retardation. *Vowel sounds* were only rarely interchanged: the nasal sounds (m, n, and ng) were usually correct (although occasionally "n" would be substituted for "ng" after the manner of our "huntin'" and "fishin'" forebears); but the sounds represented in ordinary script by the letters r, l, w, and y were fairly often substituted for each other, so that a "rabbit" might be a "labbit," a "wabbit," or a "yabbit," and a "little lamb" might be a "ritter ramb" or a "yitty yamb." The sounds of "t" and "d" were often omitted, especially at the ends of words. These same sounds, which are "front stops," were very frequently substituted for the back stops, "k" and "g" (this "cup of cocoa" became "tup of toto"); but the most frequently defective sounds of all were those of "s," "f," and "th" and their voiced equivalents "z," "v," and "th" (voiced). The "s" defects included substitutions by "th" (the common "lisp"), "sh," "t," and a sort of voiceless "l" rather like the Welsh "ll" sound in the word "Llewellyn." No less than 83% of my cases in which a defect of "s" was the sole defect present were associated with malocclusion of the jaws (Seth and Guthrie (1935) give a 90% association), and the frequency with which I either observed thumb-sucking myself or obtained a history of the habit from the mothers leaves no doubt in my mind of the permanently harmful effects of this practice. The most common substitution of all in the elementary-school children, the blind children, and the mental defectives was "f" for "th" (e.g., "thirty-three things" would be "firty-free fings"). This defect did not once occur in the secondary-school group, probably because the intelligent child, even if his hearing is slightly impaired, rapidly learns to distinguish these sounds by their lip movements and by their different visual symbols in reading-books. It was not so common in the hard-of-hearing group as defects of "s" and "r," doubtless for the same reason.

It is to Dr. Harvey Fletcher (1929), the physicist employed by the Western Electric Film Co. in research on the transmission of speech sounds, that we owe the invention of the audiometer. A complete description of the chart or audiogram and how it was evolved is given in his book. Otologists have been using the audiometer to diagnose deafness for so many years that it is unnecessary to describe it here; but for the sake of those who are not familiar with the chart it may be said that the normal "speech range" extends over some 6½ octaves, from

90 to 8,000 double vibrations per second. The "pure tone" or fundamental note of middle C on the piano is 256 (on the horizontal scale), so that we use one and a half octaves below and five octaves above this note. The line 0 represents normal hearing. The figures on the vertical scale represent the intensity of sound in decibels, 10 being approximately equal to the whisper of leaves in a faint breeze, 20 a whisper at 5 feet, 50 normal conversation at 4 feet, 75 a man shouting at 4 feet, 90 a lion roaring at 18 feet, and 110 (about the limit of human endurance) a steel plate hammered by four men (R. T. Beatty, 1932).

The late Dr. Phyllis Kerridge of University College Hospital, who first introduced audiometry into this country, said that the "middle frequencies" are the most important for speech recognition (Kerridge, 1937), but Dr. and Mrs. Ewing consider that good hearing over 250 to 5,000 d.v. is necessary for accurate appreciation of speech. Harvey Fletcher was able to show that vowels are normally heard more easily than consonants, partly because their phonetic power is higher (he says the sound "aw" has a phonetic force 680 times as great as the voiceless "th") and partly because their fundamental notes are at the lower end of the scale; although the sound "ee" (as in "speed") has important harmonic components among the upper frequencies, the sounds of "l," "r," and "ng" are the easiest of the consonants to hear. The most difficult sounds are "v," "f," and "th," which together account for more than half of the mistakes made in listening to nonsense syllables. He also noted that the sounds most often affected by "filtering out" the high frequencies were "s," "th," "z," "t," and "f." These findings are significantly comparable with my own observations concerning the sounds most often defective in school-children. In my survey I had each day noted down carefully the phonetic substitutions and omissions that came my way, but did not attempt to analyse them until the entire period of review was over. In this way I tried to eliminate all my preconceived notions regarding speech defect. Subject to the limitations of my own visual and auditory fields, the results charted were as accurate as I could make them.

As noted above, it gradually became apparent that defects (or, perhaps more accurately, immaturities) of speech sounds were associated most commonly with two groups of children—those who had impaired hearing and those who were mentally retarded. The deaf child is *organically* unconscious of certain speech sounds, since his auditory nerve is defective for that part of the range; the backward child is *functionally* unconscious of certain sounds, although his audiogram may show no defect of hearing for pure tones. The difference between the speech and attitude of the two groups of children is difficult to describe, but it is obvious enough to the trained observer to prompt thorough investigation.

Of the various types of deafness the one most commonly mistaken for mental backwardness in school is high-tone deafness. The child with impairment of low tones but good "consonant hearing" does not, in my experience, suffer a comparable educational disadvantage. He hears the vowel sounds diminished in power but normal in quality; the "speech tunes" rise and fall with their normal cadences; and, provided he can sit near the teacher, his disability will scarcely be noticed unless it is severe. The child with heavy loss over the high frequencies, however, will never be able to acquire the finer consonants naturally—that is, by ear; the speech tunes will have gaps (as if he were listening to a piano in which some of the notes were dumb), and his own speech, re-echoing as all children's speech does only the sounds that are fully appreciated, will show distortions varying in proportion to his hearing loss from mere indistinctness to gross unintelligibility. Often the good vowel hearing of these children will deceive the parent, the teacher, and the medical officer so completely that they are considered to be not deaf but stupid and obstinate. Their attainments in the basic subjects, particularly spelling and dictation, are seriously retarded and may be non-existent. Their attainments in arithmetic are usually less rudimentary and may be comparatively good, because it is easier to recognize numbers from vowel sounds alone, and the few visual symbols needed are soon learnt. (This acquired ability to recognize numbers from vowel sounds alone must always be remembered in using a grammo-

phone audiometer, especially with adults who are experienced listeners and whose minds are accustomed to "making up" the whole word from hearing a mere fraction of it.) It is probable that many of the cases diagnosed in the past as congenital word-deafness or auditory imperception were, in reality, examples of high-tone deafness. It must be obvious that an audiogram should be made of every child over 7 years old whose speech shows more than two phonetic substitutions or omissions, whether or not deafness has been suspected, and that no child showing speech defect, however slight it may seem to the untrained ear, should be certified as mentally defective without a complete investigation of the hearing.

I have come across several such cases in the course of the past year. The following are selected because they are particularly instructive and because I first suspected, from their speech alone, that the hearing for high tones was defective.

It may be noted that in each case the bone conduction as well as the air conduction is tested, but to prevent confusion these readings are omitted from the charts. One case of low-tone deafness is included for comparison. In every case clinical tests are also given. The tests used are 5 lists of 25 words each and groups of sentences standardized by Kerridge and Fry (1939).

Illustrative Cases

Case A.—Girl aged 13 years 10 months. Certified as mentally defective at 11 years with a Binet I.Q. of 50. At the retest 12 months later the I.Q. was 52. The child's speech was noted as "slightly defective." (To my trained ear after I had studied phonetics it was gross.) The defect markedly involved "s," "sh," "r," and "k."

Chart of Case A

Deafness had never been suspected at home, in school, or in the clinic. The case was re-examined finally only a few weeks before the child was due to leave school. Further training until 16 was offered but refused. Re-examination some months later was offered, but no reply was received.

Case B.—Girl aged 13 years 8 months. Certified at 9 years with an I.Q. of 67. (Later examinations gave 70.) The child's speech

Chart of Case B

was noted as "indistinct." It involved "s," "sh," and "r" principally. There was in this case a family history of deafness. The parents gratefully accepted the special training offered, and the child was admitted immediately to a school for the deaf, where she will remain until 16 years old, and where she will be taught a suitable trade.

Case C.—Boy aged 9. Referred to the clinic by his teacher as "hopelessly backward and unteachable, with very poor speech." His speech was completely unintelligible. The defect involved most of the consonants; the back vowels "oo" (pool) and "aw" (paw)

Chart of Case C

were strongly nasalized. His comprehension of other people's speech was quite good, but his scholastic attainments were *nil*. The audiogram showed very plainly the severity of his defect. He was immediately admitted to a school for the deaf.

Case D.—Boy aged 12. This was one of the most dramatic cases encountered in the research. The boy was one of a highly intelligent family of five. His speech defect markedly involved "s," "r," and "th," but his concentration was so good that, except for dictation, in which his disability caused him to appear very backward, his scholastic attainments were normal. His English composi-

Chart of Case D

tion, in which he could choose his own words, was well up to standard, and his arithmetic was good. His deafness had never been suspected either at home or in school. He had merely been considered a rather mediocre member of a clever family. He has a distinct gift for drawing, and is being referred for special training in art. He is also attending the lip-reading classes provided for all these children.

Case E.—Girl aged 11. This child was suspected of deafness at 3 years of age by her parents because she was "late in talking." Her defect involves "s," "sh," and "r" markedly. She is highly intelligent and has actually won a scholarship; she attends a secondary school, where her teachers, informed of her disability, have been able to give her special consideration. She is now successfully learning French. She is an expert self-taught lip-reader. At 3 metres, with her back turned, she did not hear a single word of the first list of 25. Facing the speaker at the same distance, she repeated 16 correctly out of the second list of 25 words. At 1 metre,

with her back turned, she heard none of the third list of 25; but, facing at 1 metre, she repeated 20 of the fourth list correctly. Her hearing for connected speech, in which the "tunes" help the sense, is (facing) 4 out of 5 at 3 metres, and 5 out of 5 at 1 metre.

Chart of Case E

Case F.—Girl aged 13. This chart of typical low-tone deafness is given only for comparison. There was a family history of

Chart of Case F (low-tone deafness)

otosclerosis. The child's speech was perfect, but very quiet. Her school work was excellent.

Conclusions

The estimation of the hearing of children by pure-tone audiometric methods is highly skilled work. Every large school medical staff should possess at least one medical officer (preferably a recognized Certifying Officer already familiar with the normal standards of intelligence and scholastic attainment) who is adequately trained in audiometry and phonetics. Smaller authorities could send their cases for investigation to the larger centres.

The hearing of all children over 7 years old who show persistent defects of articulation should be investigated by this trained medical officer. The co-operation of other school medical officers, speech therapists, and teachers in referring cases is essential.

No child with persistent defective articulation should be certified as mentally defective on the results obtained from tests involving language without an investigation of the hearing.

Accurate diagnosis of high-tone deafness is already possible. The problems of its aetiology and treatment (medical and educational) are matters urgently needing consideration.

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