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**AN EVALUATION OF PATIENTS SUSPECTED OF HAVING NOISE-INDUCED
HEARING LOSS**

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AN EVALUATION OF PATIENTS SUSPECTED OF HAVING NOISE-INDUCED HEARING LOSS

The term *noise-induced hearing loss* will be used in this paper to refer to the hearing loss that results from repeated exposure to noise over a period of months or years (11). The term, as used here, excludes hearing loss caused by physical trauma to the head or ears, explosion, or excessive changes in barometric pressure.

The relationship of hearing loss to noise exposure has been reported by many investigators (1, 4, 8, 10, 15) since the report of Fosbroke in 1831. Most of these reports are concerned with prolonged exposure to fairly constant sound-pressure levels of moderate intensity. Davis (6) was of the opinion that there is no rigid proof of permanent impairment of hearing from exposure to noise of less than 115 to 120 db. Exposure to 130 to 136 db white noise at the borax wells of Tuscany has caused hearing loss of moderate severity after 100 days of exposure (3).

Jet aircraft engine mechanics and other flight-line personnel are routinely, although intermittently, exposed to high-intensity noise during the performance of their normal duties. One present-day jet engine produces noise with an over-all sound-pressure level of approximately 140 db (fig. 1).

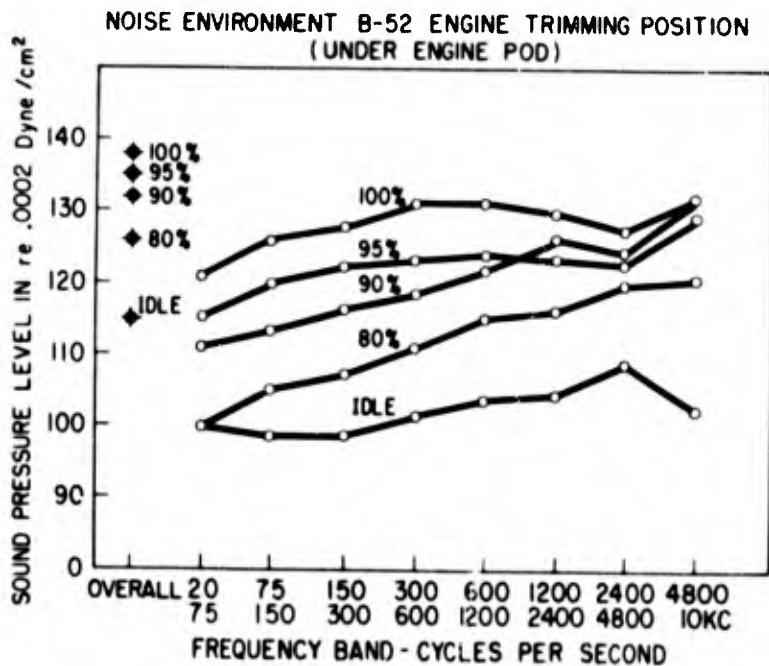


FIGURE 1

Noise environment B-52 engine trimming position (under engine pod).

A recent study of personnel exposed to jet-engine noise failed to show a significant correlation between such exposure and hearing loss although a positive correlation between age and hearing loss was demonstrated (12).

Barron (2) concluded, "Serial audiometric studies of 470 flight-line mechanics exposed to reciprocating and turbojet engine noise for periods up to seven years while employed in an air-frame manufacturing company are reported. There were no significant changes in the mean or median tests for the group at 1000 or 4000 cps frequencies other than those generally associated with presbycusis."

In another report (16) on subjects exposed to jet-engine noise and under observation for five years, it was concluded that "There is considerable indication that a certain steady-state jet-engine noise with intensity fluctuations between 90 and 120 db and with sound energy predominantly in the frequencies below 600 cps is not hazardous to the hearing of exposed personnel. None of the changes in hearing occurring in any of the subjects in this study can definitely be attributed to exposure to jet-engine noise."

The clinician is frequently called upon to determine whether a patient's hearing level¹ is caused or aggravated by noise exposure. He may be requested to give an opinion as to whether or not continuing at the present job or assignment may cause a change for the worse in the patient's hearing. It should be emphasized that studies of the type reported above involve groups of individuals and do not appreciably assist in correctly diagnosing or recommending disposition in specific cases.

This report will point out the importance of obtaining a detailed history, performing a thorough physical examination, and administering hearing tests before making a decision.

Because of these early reports it was expected that Air Force personnel who were exposed to jet-engine noise would develop hearing loss. The need for a Hearing Conservation Program was recognized by the United States Air Force. AFR 160-3, first published in 1949 and revised in October 1956, specifically relates to hazardous noise exposure and sets the following limits for lifetime exposure:

The limits for lifetime exposure to broad band noise are given in terms of the band pressure level for four octave bands. The four octave bands are 300-600 cps, 600-1200 cps, 1200-2400 cps, and 2400-4800 cps. In setting limits, it is assumed that the ears are unprotected and exposed

¹ The term *hearing level* is used here in the sense suggested by Davis et al. (7) and refers to "the deviation in decibels of an individual's threshold of hearing from the American Standard value for the reference zero for audiometers."

continuously during normal work hours over a period of 25 years. The risk of damage to hearing is slight when the pressure level of a band does not exceed 85 db. It increases as the band pressure level increases, and is excessive at 95 db.

The regulation requires that information, including a pure-tone threshold audiogram, be obtained on each person assigned to a job in which he will be exposed to noise. As a practical expedient, all individuals who work on the flight line are presumed to be exposed to a hazardous degree. The findings are recorded on AF Form 1490, "Hearing Conservation Data." The audiogram is to serve as a reference in subsequent testing. The reasons for requiring a pure-tone threshold audiogram, rather than a screening audiogram, have been reported elsewhere (13). Testing was required for the following audiometric frequencies: 500, 1000, 2000, 3000, 4000, and 6000 cps. The regulation specifies that the audiograms be classified as class A, B, or C. Class A means that there is no threshold loss greater than 15 db for any of the frequencies listed above; in other words, the hearing level is 15 db or better. Class B means that the hearing level is poorer than class A but not as poor as class C. Class C means that the hearing level is an average of 20 db or more for the speech frequencies (500, 1000, and 2000 cps) in *either* ear. A copy of AF Form 1490 is sent to the Central Repository for Hearing Conservation Data, School of Aviation Medicine, USAF. An analysis of 43,536 of these forms, for both military and civilian personnel, reveals the following: class A, 52 percent; class B, 43 percent; class C, 5 percent (17) (table I). The breakdown for military personnel

TABLE I
Distribution of hearing classifications

A	B	C	Total
Military			
17,923 58%	12,015 39%	934 3%	30,872
Civilian			
4,434 35%	6,862 54%	1,368 11%	12,664

compares favorably with a similar analysis made under research conditions (12). Greater losses were observed among the civilians—probably because they represented an older group.

Most flight-line personnel now on duty with the U. S. Air Force have not had an audiogram prior to noise exposure. The

current regulation provides that individuals who are now trained and have a class C classification on their reference (baseline) audiogram be retested after 15 hours away from noise. If the retest shows that the audiogram is still class C, another test is given after 40 hours away from noise. If the audiogram remains class C after 40 hours away from noise, the individual should be referred to a Diagnostic Hearing Center for evaluation.

This evaluation is to determine whether the individual should be allowed to continue at his present duties or be transferred to a noise-safe area which, in all probability, means retraining in another career field (job). The Air Force mission could be obstructed if a sufficient number of individuals who are trained for flight-line duties are transferred to other career fields. Because of the seriousness of this decision, the evaluation of individuals having a class C audiogram or significant threshold shift should be made by a physician with special training in this field of medicine. The number of otolaryngologists in the U. S. Air Force is limited. A hospital is designated as a Diagnostic Hearing Center only when a Board-certified or Board-eligible otolaryngologist is assigned to that hospital. It is desirable that a clinical audiologist also be assigned to these centers. The centers are so located throughout the United States and overseas areas that their services are available without requiring prolonged travel on the part of the patient.

The School of Aviation Medicine, USAF, was designated as a Diagnostic Hearing Center on 29 October 1956. The author has had the privilege of evaluating a small number of Air Force personnel who were presumed to have received hazardous noise exposures and who were found, at their duty station, to have a class C audiogram. They were trained personnel who had been in the military service for periods of less than 1 year to more than 30 years. Reference audiograms were not available on any of the patients.

Among the factors considered to be important in the evaluation were the medical history, occupational history, family history, physical examination, hearing tests, estimate of actual noise exposure, and presbycusis.

Items considered of particular interest in the medical history were: hearing loss since childhood; meningitis or systemic infection; mumps; head injury with drainage of blood from the ear, loss of consciousness, or vertigo; injury to the ear from a foreign body, blast, or blow to the ear; earache, drainage from the ear, or decreased hearing associated with a common cold or following aerial flight; medications — such as streptomycin, dihydrostreptomycin, and quinine — known to have an effect on hearing; awareness of hearing loss by the patient and time of onset; and, finally, results of previous physical examinations and hearing tests.

The occupational history included: military history; hunting or frequent use of firearms; previous employment, particularly with regard to noise exposure; present assignment, length of time on the present assignment; tinnitus or temporary threshold shift at the end of a work day or work week.

The family history was obtained with reference to defective hearing. When the history was positive, an evaluation of other members of the family would have been of inestimable value in arriving at a diagnosis.

The physical examination was carefully performed. Particular attention was given to evidence of disease or injury (active or healed) of the external ear, middle ear, or eustachian tube, which might affect hearing. It was kept in mind that fluid in the middle ear may cause a high tone loss simulating a perceptive loss (14). In unilateral perceptive-type cases a caloric test was carried out. The effect of age on auditory acuity was considered (4,5).

The hearing tests were performed in a room in which the ambient noise was such that it did not mask the true audiometric thresholds. Suitable standards for ambient noise within the test booth have been suggested by the Subcommittee on Noise in Industry of the American Academy of Ophthalmology and Otolaryngology (9).

A pure-tone threshold air conduction and bone conduction audiogram constituted the minimum hearing test. The tests were performed on an audiometer which was calibrated according to the specifications prepared by the American Standards Association. Speech reception threshold (SRT) and discrimination tests are an invaluable adjunct in evaluating the patient's hearing for speech. Speech tests were accomplished whenever indicated. The speech reception threshold was obtained by use of laboratory equipment and the W-2 recordings. The discrimination score was obtained by use of the same equipment and Russ Hughes recordings. The scores on normal individuals in our laboratory range between 75 and 85 percent. A recruitment test may aid in differentiating between cochlear and retrocochlear perceptive-type losses; however, it is a difficult test to perform when losses in the two ears are equal. All tests were performed by an individual who had been specially trained to test hearing.

As a result of procedures such as those outlined above 77 cases referred to the Diagnostic Hearing Center, School of Aviation Medicine, USAF, were diagnosed as follows:

- | | |
|---|----|
| 1. Conductive | 29 |
| a. Otitis media, chronic (active or healed) | 11 |

b. Otosclerosis	17
c. Atresia, external auditory meatus, congenital	1
2. Functional	7
a. Psychogenic	2
b. Voluntary (malingerer)	5
3. Perceptive	41
a. Unilateral	22
b. Bilateral	19

COMMENTS

It is believed that noise exposure definitely was not the main cause for a class C audiogram in the conductive cases.

With reference to the functional cases, the hearing level of the 2 classed as psychogenic may have been contributed to indirectly by noise exposure but a basic psychiatric disturbance was in operation. The 5 diagnosed as voluntary functional cases were found, after repeated tests, to have essentially normal hearing.

The perceptive-type cases were categorized as being unilateral or bilateral. Medical histories of the unilateral perceptive cases were revealing. Of the 22 unilateral cases, 9 patients gave a history of head injury with loss of consciousness and each was aware of defective hearing afterward; 9 gave a history of defective hearing since childhood, cause unknown; 1 patient had experienced a sudden loss of hearing while on furlough, and 3 could not date the onset of defective hearing although each individual stated that he had been aware of it for several years. One patient who had no history of head trauma had an absent caloric response and unilateral deafness. He was referred for a neurologic consultation because of the possibility of acoustic neuroma. In none of the unilateral perceptive types was noise exposure felt to be the main cause for a class C audiogram.

Since only the bilateral perceptive-type cases are now suspected of noise-induced hearing loss, a presentation of the audiometric findings and an extract of the pertinent history of these cases are in order.

Case 1. (F. W. E. M/Sgt. Age, 38) The patient worked as mechanic on conventional aircraft from 1942 to 1956. During 1956 and 1957 he was "line chief" for a squadron of F-89's. He first noted hearing loss 9 months previously. The audiometric findings were as follows:

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC-Right	25	25	25	25	50	65	NR	NR	17	78
Left	20	25	30	35	60	65	NR	NR	24	80
BC-Right	20	20	20	20	NR	NR				
Left	20	20	40	35	NR	NR				

Case 2. (C. B. R. Civilian. Age, 42) The patient has worked as a mechanic on conventional aircraft for 17 years. Defective hearing was noted during his physical examination for separation from the Navy in 1945. He does not feel that defective hearing handicaps him either socially or at work. He gives no history of temporary threshold shift after a work day.

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC-Right	5	20	60	NR	NR	NR	NR	NR	46	24
Left	0	15	65	NR	NR	NR	NR	NR	45	22
BC-Right	5	10	65	NR	NR	NR				
Left	10	20	65	NR	NR	NR				

Case 3. (J. D. P. T/Sgt. Age, 34) The patient has 16 years' military service. He was a mechanic on conventional aircraft until 1955. Since then he has worked on jet aircraft. He has noted defective hearing for several years.

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC-Right	0	15	35	65	75	80	70	55	36	44
Left	0	15	45	65	75	75	NR	55	36	52
BC-Right	0	25	30	NR	NR	NR				
Left	-10	30	45	NR	NR	NR				

Case 4. (R. A. Z. A/2C. Age, 22) The patient was exposed to considerable noise of heavy weapons fire while in an Army artillery division during the Korean conflict. He noted defective hearing and tinnitus at the time of discharge from the Army. He enlisted in the U. S. Air Force 22 April 1957.

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC-Right	25	40	35	40	65	70	70	40	37	70
Left	25	35	40	40	65	75	75	50	35	64
BC-Right	30	45	35	35	NR	NR				
Left	25	35	35	35	NR	NR				

Case 5. (A. B. M. Civilian. Age, 58) The patient retired from the Army in 1950 after 30 years' active service, most of which time he worked as mechanic on conventional aircraft. Since retirement from the military service he has done the same type of work as a Civil Service employee. He has fired small weapons all his life.

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC-Right	10	20	40	55	65	60	55	45	34	52
Left	5	30	50	60	65	60	55	55	41	44
BC-Right	-10	-10	20	50	NR					
Left	-10	-10	40	55	NR	NR				

Case 6. (E. R. Civilian. Age, 44). The patient, a mechanic on conventional aircraft for 12 years, has been aware of defective hearing for 2 or 3 years.

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC-Right	0	10	25	50	70	60	40	45	32	60
Left	10	10	30	60	70	65	50	55	30	52
BC-Right	10	20	30	50	NR	NR				
Left	10	0	15	NR	NR	NR				

Case 7. (R. M. M. Civilian. Age, 54) The patient has been mechanic on conventional aircraft for the past 11 years. There is no other history of noise exposure. He occasionally has high-pitched tinnitus.

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC-Right	15	15	25	35	45	50	55	20	25	68
Left	5	10	20	30	45	50	50	30	20	88
BC-Right	20	30	35	35	40	45				
Left	10	20	30	35	45	40				

Case 8. (R. H. H. M/Sgt. Age, 50) The patient has 16 years' military service. He was in the infantry for 15 months in World War II, during which time he was frequently exposed to machine gun, carbine, and howitzer fire. He has been aware of defective hearing since 1945.

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC-Right	10	25	35	45	60	75	65	70	24	72
Left	15	30	40	65	65	75	60	65	43	52
BC-Right	15	25	35	50	NR	NR				
Left	20	35	45	NR	NR	NR				

Case 9. (R. O. B. A/2C. Age, 26) While the patient was in the Army in 1951 a 90- or 120-mm. howitzer was fired near him. He had tinnitus for 8 hours afterward. He hunts frequently. From December 1956 to June 1957 he was exposed almost daily to the noise of small arms fire on a rifle range. Since June 1957 he has been exposed to jet-aircraft noise.

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC-Right	20	30	30	35	55	60	60	55	36	64
Left	35	35	35	35	60	60	65	55	38	60
BC-Right	25	35	35	45	55	55				
Left	25	30	30	35	60	55				

Case 10. (W. F. F. S/Sgt. Age, 27) The patient aircraft, he was exposed to the noise of 8,000 to 13,000 rounds of ammunition daily for 1 year. He had tinnitus noted defective hearing while in Korea in 1951. He first for 2 or 3 hours every evening but noted no temporary bore-sighting 50-caliber machine guns on F-86 type threshold shift.

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC-Right	15	20	40	40	55	50	50	50	24	48
Left	20	15	25	50	55	55	55	40	23	70
BC-Right	15	15	40	50	55	50				
Left	5	15	40	30	55	45				

Case 11. (D. J. F. A/3C. Age, 21) The patient, type tinnitus since childhood and has had recurrent who has had 38 months' service in the U. S. Air episodes of otitis media. As a child, he had a simple Force, has done armament work for 12 months. He mastoidectomy on the left side. Examination revealed fires small arms frequently. He has had pure-tone marked scarring of the tympanic membranes.

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC-Right	15	25	30	20	70	70	60	55	28	75
Left	15	20	25	45	75	75	70	50	33	66
BC-Right	5	10	20	20	NR	NR				
Left	—	5	30	35	NR	NR				

Case 12. (D. D. F. S/Sgt. Age, 23) The patient aid. There was no significant change in his audio-gram between May and December 1957. history reveals that his grandmother wears a hearing

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC-Right	-5	10	20	50	50	45	35	35	18	66
Left	-10	5	15	50	50	50	40	40	13	82
BC-Right		10	20	50	55	NR				
Left		10	20	NR	NR	NR				

Case 13. (H. A. S. M/Sgt. Age, 36) The patient developed a "humming, buzzing-type ringing" in the left ear following a flight from Japan to California in October 1957 and has been aware of defective hearing since then. His father has defective hearing.

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC-Right	15	20	45	45	50	55	65	30	41	54
Left	15	15	35	50	65	60	65	45	43	48
BC-Right	20	35	50	35	NR	45				
Left	20	20	30	NR	NR	NR				

Case 14. (H. W. N. S/Sgt. Age, 48) The patient has had 15 years of military service. He was assigned with the Air Police for 3 years but rarely fired a weapon. For the past 3 months he has worked in a hangar close to T-37 type operating aircraft. He is unaware of defective hearing. He rarely flies. His father has defective hearing.

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC-Right	0	10	20	25	50	65	70	80	18	86
Left	0	10	25	25	40	40	50	55	25	82
BC-Right	10	15	20	30	55	NR				
Left	5	-5	5	30	40	55				

Case 15. (R. C. T/Sgt. Age, 27) From 1947 to 1955 the patient worked as a mechanic on conventional aircraft. During 1955 and 1956 he was a mechanic on the B-47 type multiple jet bomber. He has had no serious noise exposure since 1956. Both parents have defective hearing.

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC-Right	55	70	65	60	65	55	50	45	67	50
Left	35	35	40	25	25	25	15	30	37	44
BC-Right	35	25	50	50	50	45				
Left	15	15	25	30	30	15				

Case 16. (M. W. B. T/Sgt. Age, 28) While in high school the patient quit a job in a factory because the noise made him nervous. In 1949 he had mumps. During his hospitalization an audiogram was performed and revealed defective hearing. His father developed defective hearing at an early age. His brother, sister, and paternal grandfather have defective hearing.

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC-Right	20	20	30	45	50	55	50	45	37	44
Left	10	20	30	45	50	55	55	45	32	48
BC-Right		25	30	NR	NR	45				
Left		25	35	45	45	50				

Case 17. (M. R. C. A/1C. Age, 25) When the patient was 12 years old, a firecracker accidentally exploded close to his ear. He had a temporary threshold shift and tinnitus for several hours afterward. Prior to entering the U. S. Air Force he was employed for 6 years in aircraft companies as a sheet metal worker, riveter, and punch press operator. He operated a jack hammer for 6 months. He is now a B-36 mechanic but is rarely exposed to noise.

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC-Right	-5	-5	-5	15	75	75	75	50	5	50
Left	15	25	NR	NR	NR					
BC-Right	0	0	-10	15						
Left	20	15	NR	NR						

Case 18. (W. J. B. A/2C. Age, 22) The patient is an Air Policeman who works as a security guard on the flight line. He was an aircraft mechanic in the Navy from 1952 to 1955. He is unaware of defective hearing. In 1949 he had a head injury which resulted in loss of consciousness for 20 minutes.

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC-Right	10	15	20	25	50	50	30	40	19	60
Left	0	10	20	20	30	30	20	25	14	74
BC-Right	5	0	20	25	55	40				
Left	5	10	25	30	20	25				

Case 19. (M. L. H. S/Sgt. Age, 26) The patient has 6 years' military service. During this period he has done aircraft sheet metal work requiring the use of riveting machines and sheet metal presses. He has noted some difficulty in understanding speech for about 2 years. He does not feel that his hearing loss is progressive. At age 15 he had a head injury with loss of consciousness for 2 minutes.

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC-Right	-5	-5	10	70	75	80	NR	NR	13	72
Left	-5	5	15	60	75	95	NR	80	13	50
BC-Right	0	-10	5	NR	NR	NR				
Left	0	10	15	NR	NR	NR				

DISCUSSION

Inasmuch as reference audiograms had not been done on these patients, it was impossible to determine if there had been a threshold shift. (Since 10 March 1957 every individual entering the U. S. Air Force has had a pure-tone threshold audiogram as part of his routine physical examination.) The audiometric curves obtained on many of the patients were not of the type usually found in noise-induced hearing loss.

It is suspected that poor hearing probably had been present for many years in those patients who stated that they were unaware of hearing loss. A family history of hearing loss was obtained from a few of them. At present, it is impossible to determine whether most of these patients had actually received a hazardous noise exposure. With equipment now available, the duration of an individual's exposure to a given sound-pressure level on a flight line cannot be measured conveniently or accurately because the noise level fluctuates almost continually, and personnel move into and out of the noise areas sporadically. Most of these patients were returned to their previous assignments. All of them were urged to wear ear protection, and they were requested to return in one year for further evaluation. It is hoped that an evaluation of these individuals after they have been an additional year at their normal place of duty will prove rewarding.

SUMMARY

The results of an evaluation of 77 U. S. Air Force flight-line personnel with defective hearing are reported. The evaluation revealed that 29 patients had a conductive-type, 7 had a functional-type, and 41 had a perceptive-type defect. Twenty-two of these perceptive cases were unilateral. In only 19 cases was noise exposure considered to be a possible cause of defective hearing. The difficulties encountered in attempting to determine whether defective hearing in a specific patient is caused or aggravated by noise exposure are discussed.

CONCLUSIONS

The greatest difficulty encountered in evaluating these patients was the lack of a reference audiogram. Until a method or device is developed to measure the noise exposure each individual receives, or until it is proved that intermittent exposure to high-intensity noise causes hearing loss, the judgment of the examining physician will be greatly taxed in determining whether the hearing level in a specific patient is caused or aggravated by noise exposure. But even so, careful history-taking and medical examination are needed to rule out other influences. By obtaining detailed histories, performing thorough physical examinations, and administering hearing tests, it was possible to eliminate 58 out of 77 patients with class C hearing who were suspected of having a noise-induced hearing loss.

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