

THE VIBROACOUSTIC DISEASE: SOME FORENSIC ASPECTS

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SUMMARY

Introduction. The Vibroacoustic Disease (VAD) is an insidious environmental entity caused by occupational exposure to Large Amplitude (≥ 90 dB), Low Frequency (≤ 500 Hz) (LALF) noise. Significant disabilities may result, and issues of worker's compensation should be openly discussed and settled. Toward this goal, a rigorous re-check of all available information on this disease was undertaken, in order to define the industrial exposure standards and settle upon the diagnostic procedures that will help distinguish the VAD from other, similar conditions. *Population And Methods.* We reviewed the medical files of 236 male Caucasians who had been diagnosed with VAD and monitored for at least 15 years. The natural history of the disorder was studied in detail, emphasizing the clinical diagnostic criteria and the outcome of disabilities. *Results.* Among the 236 cases, 172 (73%) were disabled after an average of 24 years (SD = 6.9) of occupational exposure. The most important primary causes of disabilities were neurological (81, 34%), malignancy (28, 11.9%), psychiatric (23, 9.7%), cardiovascular (16, 6.8%), and osteoarticular (14, 5.9%). After the onset of industrial exposure to LALF noise, the minimum time for these disabilities to manifest themselves was 16 years. The most serious complication was multiple attempted suicide. Such attempts were fortunately rare (5, 2.1%) and successful only once. This is possibly linked to a marked incompatibility of VAD subjects with social environments, which has not been reported in subjects exposed to large amplitude, *high* frequency noise. Echocardiograms showed characteristic changes in pericardial structures, involving proliferation of the extracellular matrix, lack of cilia and 5 pericardial layers instead of 3. This has been studied in pericardial biopsy material obtained during coronary bypass surgery for coronary insufficiency (6 cases), and by autopsy (4 cases). *Discussion.* These findings appear to be pathognomonic for the VAD, and the echocardiogram has been confirmed as a fundamental diagnostic tool. The degree of disability due to VAD can be determined from Portuguese national disability tables, which cover almost all of the VAD-induced disabilities. However, these tables do not specify LALF noise as an occupational hazard, rendering them irrelevant to VAD patients. Also, suicide, a most serious psychiatric consequence, is not covered by these tables. Such situations highlight the absolute necessity to recognize LALF noise as the cause of VAD, and as an industrial hazard.

INTRODUCTION

The Vibroacoustic Disease (VAD) is an insidious environmental pathology caused by occupational exposure to large amplitude and low frequency (LALF) noise (≥ 90 dB, ≤ 500 Hz). Significant disabilities may result, and issues of worker's compensation for such disabilities should be openly discussed and settled. Because VAD is a newly recognized occupational disease it is still non-existent from a forensic standpoint. The available data attest to the enormity of the problem. Low frequency noise is ubiquitous and can be harmful not only in workplaces, but also in leisure activities or even at home. The affected population is so large, and the sources of low frequency noise so varied, that any initiative in the medical forensic domain has to be rigorous as it is openly undertaken.

Regarding noise, the only disability recognized by law is noise-induced hearing loss. In our patients, the classical acoustical scotoma at 4 kHz is not as frequent as expected, given the high dB-level of the noise environment. Their hearing loss at frequencies below 500 Hz is often more severe than the loss observed at 4 kHz. These patients exhibit some important features, such as noise intolerance - a recruitment-like phenomenon, - and balance disturbances that are associated with asymmetries in brainstem evoked potentials. Clinical situations can be

considered work related and therefore entitled to compensatory measures when the source of disability or injury is established as job-related. The most important disorders associated with the VAD are not legally recognized as noise-induced. They often lead to anticipated retirement, permanent disability, or even death. The employees are not entitled to any type of Worker's Compensation, and the costs are solely supported by the national health care system. An effort should be made to establish the specificity and recurrence of disabilities due to VAD. Our group has been working on this project for the past 19 years. We believe that there is finally enough evidence to confidently and vigorously approach this sensitive matter.

The primary goal of this paper is to urge appropriate authorities to officially acknowledge LALF noise-induced pathology, the VAD, as an occupational disease, based on the knowledge of the following factors: a) a well-established and reproducible cause-effect relationship; b) a successful diagnostic methodology; c) the disabilities incurred by workers in these environments; and d) incomplete noise assessment guidelines. The purpose of this legislative and legal identification would be: a) to protect the worker; b) to lower health care costs; c) to entitle patients to the appropriate worker's compensation; d) to avoid premature retirement and the unnecessary progression of disabilities; and e) to revise recommended noise assessment requirements.

POPULATION AND METHODS

We reviewed the medical files of 236 male Caucasians diagnosed with VAD and monitored for at least 15 years. Selection criteria of the study group is described in Ref. 3. All were employed by OGMA¹, as aircraft technicians. Noise assessment was performed in a previous study (2) and demonstrated a prevalence of high amplitude (≥ 100 dB) and low frequency (≤ 500 Hz) noise. Infrasound was not assessed. The clinical evolution of the disorder was studied in detail (3), keeping in mind the need for industrial exposure standards. The validity of diagnostic tests was also evaluated, keeping in mind the need for a systematic diagnostic procedure that would distinguish the VAD from other clinical conditions.

RESULTS

Table I: Disabilities Observed In 236 VAD Patients

Primary Causes Of Disability	No. of Cases	ExpTime (yr)		Age		No. of Retirees	On Active Duty
		Ave	SD	Ave	SD		
Late Epilepsy	26	16	4.4	44	9.8	24	2
Stroke	19	24	6.1	46	6.7	18	1
Vision	21	26	5.1	46	5.1	16	5
Auditory	15	33	3.4	53	2.9	14	1
Psychiatry	23	22	5.8	46	7.2	22	1
Malignancy	28	23	6.2	43	6.4	26 ^a	2
Osteoarticular	14	30	4.4	53	3.8	14	0
Cardiovascular	16	26	2.5	49	4.8	15 ^b	1
On-The-Job Accidents	5	24	3.7	50	2.5	5	0
Other Non-Frequent Causes	5	21	7.5	39	7.5	5	0
Total	172	24	6.9	47	7.1	159	13

a) 13 are deceased.

b) 4 are deceased and 6 have received coronary bypass surgery.

See Table I. Among the 236 cases, 172 (73%) were disabled after an average of 24 years ($SD \pm 6.9$). The results are summarized in Table II. Primary causes of disabilities were neurological (81, 34%), malignancy (28, 11.9%), psychiatric (23, 9.7%), cardiovascular (16, 6.8%), and osteoarticular (14, 5.9%). The minimum time for these disabilities to manifest themselves after the onset of industrial exposure to LALF noise was 16 years.

The most serious complication was attempted suicide; this was fortunately rare (5, 2.11%), and was successful only once². This action is possibly linked to a marked incompatibility of VAD subjects with social environments, a finding which has not been reported in subjects exposed to large amplitude, *high* frequency noise.

¹ OGMA, S.A., founded in 1918, is an aircraft manufacturing, repair and rehaul facility.

² At the time of publication, a second patient of our study group was successful in his attempt.

Echocardiography showed characteristic changes in pericardial structures, involving proliferation of the extracellular matrix, lack of cilia, and the presence of 5 distinct layers instead of 3. This was found in pericardial biopsy material obtained during coronary bypass surgery for coronary insufficiency (6 cases), and by autopsy (4 cases) (4). In 64 cases (27.1%), no disabilities developed. The pathologies in this group are discrete, very mild and have not evolved to the point of disability.

DISCUSSION

The VAD is not legally recognized as a cause of occupational disability. Unmonitored, it can lead to disability retirement. The evolution of VAD has been described, and broken down into distinct phases (3). Cardiovascular (5) and neurological (6) diagnostic methods have been outlined for the clinical practitioners. The evolution of this occupational disease can be monitored, and permanent disabilities can be avoided. The discrete pathophysiological mechanisms of the VAD are known. These include low plasma cortisol and prolactin levels, high norepinephrine levels in susceptible individuals, changes in coagulation factors, changes in lymphocyte and cytokine populations, and the morphological and ultra-structural changes that explain most of the observed clinical situations. LALF noise is not acknowledged as a cause of any of these diseases or disabilities, rendering the tables inapplicable to our patients, and denying them Workers' Compensation rights. Such situations highlight the absolute necessity that legislators and regulators acknowledge LALF noise as an occupational hazard, and the VAD as an occupational, noise-induced, extra-aural pathology.

Noise regulatory guidelines regarding both exposure to LALF and assessment of VAD are, at best, incomplete. Recorded overall exposure time is not uniform throughout the different occupational noise environments. For example, military and commercial pilots have a daily and hourly log in which their flights are meticulously recorded. But industry workers are exposed to a variety of occupational noise environments during the workday, for an indeterminate number of hours. The accumulation of noise exposure is not uniformly quantified. Since the VAD is an insidious disease, that evolves over prolonged or repeated exposure to LALF noise, total exposure time should be measured in years. Recovery rates must also be taken into account. The recovery time required after a 4-hr flight is well-defined. However a 7-hr flight has a different recovery time and a flight of 10 hr or more has a completely distinct recovery pattern. Such recoveries are not a linear process and this must be recognized.

Acoustic phenomena does not impinge only on the auditory system, yet only *hearing loss* is identified as a noise-induced injury, and regulated as an occupational, noise-induced hazard. Noise, as a wave phenomenon, is only clearly defined if *both* amplitude and frequency are established. In current occupational noise assessment guidelines, frequency analysis is not mandatory. Noise is merely quantified in terms of the dB-level. This is incomplete. Information on the frequency distribution must be obtained whenever industrial noise assessments are required.

When neurological changes, such as balance disturbances, epilepsy and stroke, occur in workers occupationally exposed to noise, a diagnosis of VAD should be suspected. An echocardiogram is mandatory to validate the diagnosis. This test provides information on whether or not LALF noise-induced pathology is occurring, as well as on the stage of development of the disease. In the particular case of stroke, carotid echo-Doppler should be performed. Additionally, EEG, Multi-modal Evoked Potentials, and MRI can further corroborate a VAD diagnosis.

Malignancy is not the most frequent occurrence (28 cases, mean age 43 ± 6.4 yr), but its incidence does have peculiarities. Five of these 28 patients had multiple malignant formations. All of the tumors of our patients occurred within hollow organs, with the exception of the brain (5 cases, all glia-type) and soft tissue (1 case). The occurrence of brain tumors may be partially explained by the skull acting as a resonance box within the LALF noise environment. Since there is only a single case of soft tissue tumor, no speculations can be made. There were 5 cases of malignant lung lesion, all epidermoide carcinoma, and 2 of these occurred in non-smokers. In the general population, epidermoide carcinomas are not the most frequent type of lung tumor. Aspects of low-grade differentiation of the tumors is also distinctive.

Suicide, the most serious psychiatric consequence of VAD, is not covered by the Portuguese National Table of Professional Diseases and Disabilities. Five of our patients made multiple suicide attempts, and one was successful at his third try (please see Footnote 2). These patients behave differently from the customary suicidal patient. They do not feel shame for what they have done and, in fact, do not really remember what they did. They are confused

about the entire incident, which itself is unprepared and disorganized. These suicidal patients do not fit into the normal suicidal behavior patterns.

In our study population, 158 individuals (67%) suffered on-the-job accidents, with 1 fatality and 4 permanent disabilities. These 5 cases were entitled to Worker's Compensation. Of the 158, 49 suffered only one accident, 109 suffered more than one accident, and in 55% the accidents occurred in the first 3 years of service. These values are not very different from those of a previous study on on-the-job accidents among VAD patients (1). Three of the 236 VAD patients currently receive 30% disability for noise-induced hearing loss. Within the group of 236 VAD patients, only 8 have been entitled to Worker's Compensation, despite the vast amount of serious disabilities. None of the Worker's Compensation is due to extra-aural, noise-induced pathology.

It is easy to determine noise as the cause of many pathologies associated with VAD. However, in many cases, excessive noise exposure may not be the obvious culprit. For example, coronary insufficiency has many causes, and may lead to bypass surgery. This is a high-cost surgery for which the national health care system foots the bill. However, this coronary insufficiency could be due to previous occupational noise exposure, or other causes. If an inquiry into the patient's occupational background reveals exposure to noise environments, an echocardiogram would confirm or deny a VAD diagnosis. This evidence could be corroborated by additional, more expensive, diagnostic tests, such as, Brain MRI and Brainstem Evoked Potentials. If VAD is indeed diagnosed, this acknowledges that the injury was incurred through the patient's occupational activity; i.e., on-the-job. Should the taxpayer then be solely responsible for the costs? Should the national health care system financially support this type of on-the-job injury? These are very serious questions. Evolution of VAD could be monitored, permanent disabilities avoided, and healthcare costs greatly reduced.

CONCLUSIONS

Enough evidence has come to light to warrant the recognition that

- LALF noise is an industrial hazard;
- the VAD is an occupational, noise-induced, extra-aural pathology, caused by chronic exposure to LALF noise;
- VAD patients are entitled to Worker's Compensation;
- noise-environment industries should implement echocardiography monitoring in all exposed workers.

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