Presbycusis and Fitness to Fly

Stanislas Ballivet de Régloix; Louise Genestier; Olga Maurin; Salome Marty; Anna Crambert; Yoann Pons

BACKGROUND: When a pilot is referred for presbycusis, his flight fitness may be questionable. The objective of this retrospective study was to describe a case series of presbycusis in a pilot population and to discuss the decisions about their flight waivers.

METHODS: There were 19 pilots who were referred to the ENT-Head and Neck Surgery Department of the National Pilot Expertise Center. Their medical files were retrospectively examined.

RESULTS: Of the 19 patients, 5 did not obtain flight fitness waivers. Among the 14 who received waivers, 7 had no restrictions on their flight fitness.

DISCUSSION: Flight fitness was based on the maximum percentage of speech recognition and the slope of the curve for speech recognition in speech audiometry in noise and the follow-up of these findings. The results made it possible to determine a patient's fitness to fly with a waiver, which may be associated with restrictions. In our series, only 5 pilots out of 19 did not obtain a flight fitness waiver. The few published studies on the resumption of flight for patients who had presbycusis and our experience in France with similar waivers in commercial and military aviation suggest that under certain conditions and after relevant cochlear assessment, presbycusis may allow for a safe pursuit of aviation activity.

KEYWORDS: expertise, flight fitness, presbycusis, speech audiometry in noise.

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Age-related sensorineural hearing loss, or presbycusis, has a significant socio-professional impact. It may progressively compromise the practice of a profession or leisure activity through impaired communication, particularly when hearing is supervised by regulatory standards.[5] Pilots involved in commercial aviation require a first-class medical certificate (Class I) and general aviation pilots (that is, those not involved in commercial activities) require a second-class medical certificate (Class II).[4] These pilots are subject to hearing performance standards with regular follow-up of these findings, which are required not only as consequences of ensuring flight safety but also as a preventive measure due to the chronic noise exposure experienced by the pilots. When a pilot is referred for presbycusis, his flight fitness often becomes questionable. The objective of this retrospective study was to describe a case series of presbycusis in a pilot population and to discuss the decisions about their flight fitness.

METHODS

Subjects

In French aviation (civilian and military), nearly 16,000 experiments are conducted on aircrew members (4000 pilots) in the ENT-Head and Neck Surgery Department of the National Pilot Expertise Center (Clamart, France) each year. The mission of this center is to select and monitor aircrew with specialized expertise in aeronautics, naval and aerospace operations. It is the main center for military personnel and it supports many individual (private) pilots and those employed by commercial airlines. When sensorineural hearing loss suggestive of presbycusis is identified during a routine visit, the staff records this information into a register, which allowed us to locate these patients' ENT records for analysis.

Presbycusis is defined as a bilateral sensorineural hearing loss, symmetrical and first affecting high frequencies, without otological antecedent that could explain this hearing loss and without known antecedent of other hearing loss, occurring in individuals starting from 45 yr of age. The inclusion criterion

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for this study was a finding of recent sensorineural hearing loss, bilateral and predominant in high frequencies in patients with audiograms outside the French proficiency standards.[12,13]

The exclusion criteria were patients younger than 45 yr old, with a history of tympanoplasty, chronic otitis, acute hearing trauma, as well as patients with clinical tympanic abnormalities or asymmetry to pure-tone audiometry. Patients with hearing aids were not excluded because of the possibility of a fitness to fly with hearing aids, but tests were carried out without hearing aids.

The examination aimed to determine the possibility of granting the patient a flight waiver. The hospital ethics committee exempted this study from the need for consent because it only involved retrieving data from medical records (Scientific Committee for Clinical Trials of the Percy Hospital, September 2018).

Procedure

Our study focused on patients with expertise records examined between 2012 and 2015. It involved all pilots who presented with presbycusis responsible for unfitness to fly during the course of systematic monitoring at the ENT-Head and Neck Surgery Department of the National Pilot Expertise Center. The medical files were retrospectively examined, and the following data were analyzed:

- Age, gender, job, date of diagnosis, use of hearing aids,
- Pure-tone, speech audiometry in quiet and speech audiometry in noise (65 dB), with speech recognition threshold, also called speech reception threshold (the level of intensity that someone can detect words 50% of the time), speech discrimination score, also called word recognition score (maximum percentage of speech recognition) and the slope of the curve for 50–100% speech recognition [(100% threshold value – 50% threshold value)/50] (**Fig. 1**);
- Mean hearing loss (MHL) in each ear [(500 Hz + 1000 Hz + 2000 Hz + 4000 Hz)/4] and total mean hearing loss [(right MH + left MHL) / 2];
- Class I or Class II medical fitness certification;
- Number of hours of flight;
- Fitness to fly results.

Statistical Analysis

Statistical analysis was performed with SPSS/PC software version 10.0 (SPSS Inc. USA). The Mann–Whitney *U*-test was used to compare quantitative data, and the Chi-squared test was used to compare qualitative data. The differences were considered significant at a *P*-value less than or equal to 0.05. The analysis aimed to illustrate and explain the purpose of the discussion, i.e., the fitness-to-fly decision.

RESULTS

The files of 19 pilots (18 men and 1 woman) were collected and analyzed (**Fig. 2**) (**Table I**). The pilots were divided into the following categories: military pilots ($N = 2$), line pilots ($N = 4$), and class II pilots ($N = 13$). The patients were, on average, 64 ± 11.4 yr old at the time of examination. The number of hours of flight was 7840 h on average, with a wide disparity depending on the class (13,691 h for class I, 3496 h for class II). Five Class II pilots and one Class I pilot had hearing aids. There were 14 pilots who had obtained a waiver. Of those 14 pilots, 7 were declared fit to fly with restriction (ANR aviation headsets, dual-control with a second, normal hearing, qualified pilot). Five pilots were declared unfit to fly, including one Class I pilot.

The mean hearing loss was 41 dB for the right ear and 38 dB for the left ear. The total mean hearing loss was 39 dB. Concerning the pure-tone audiometry, there was no significant difference between the two ears, either in the fit-to-fly group or in the unfit-to-fly group (**Fig. 3**). The initial flight unfitness determination depended on the loss of high frequencies, beyond 2000 Hz in pure-tone audiometry, which led to expertise with speech audiometry.

Among the five pilots who did not receive waivers, two did not reach 100% speech recognition for at least one ear, and one out of these five pilots did not achieve 100% speech recognition for speech audiometry in quiet. The Class I pilot (line pilot) who did not receive a waiver was declared unfit to fly because of auditory fatigability associated with disabling tinnitus. The maximum percentage of the speech recognition threshold was significantly higher for the unfit-to-fly group. The speech recognition thresholds were comparable (**Table II**). Concerning the maximum percentage of speech recognition, 100% speech recognition was not obtained systematically, making it impossible to establish a reliable growth curve. An arbitrary 100% speech discrimination level was defined at 120 dB for the calculation of the slope of the curve.

The slope of the curve for 50–100% speech recognition in speech audiometry in noise for the right ear was significantly better for the fit-to-fly group (**Table III**).

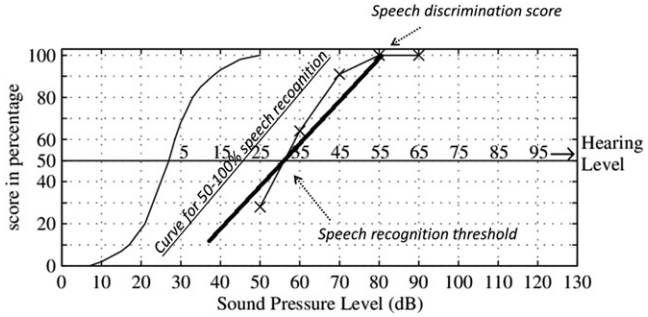

Fig. 1. Speech audiometry.

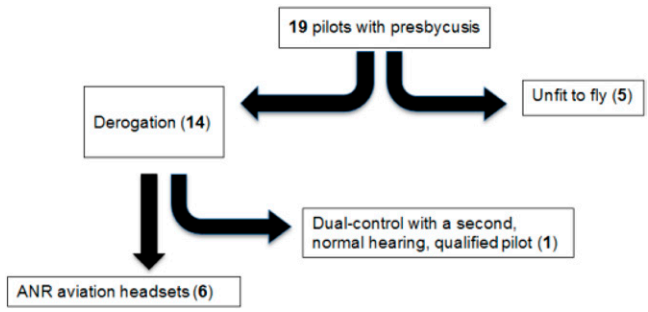

Fig. 2. Decisions about flight fitness.

Table I. Summary Table.

PATIENT	AGE	GENDER	CLASS MEDICAL CERTIFICATE	MILITARY/CIVILIAN	NUMBER OF FLIGHT HOURS	HEARING AIDS	FLIGHT APTITUDE
1	78	M	II	Civilian	1036	-	Unfit to fly
2	72	M	II	Civilian	804	-	Unfit to fly
3	73	M	II	Civilian	-	yes	Derogation
4	81	M	II	Civilian	-	yes	Unfit to fly
5	85	M	II	Civilian	7010	yes	ANR aviation headsets
6	65	M	II	Civilian	-	-	Derogation
7	55	M	II	Civilian	9700	-	Unfit to fly
8	53	F	II	Civilian	480	yes	Derogation
9	57	M	II	Civilian	-	-	ANR aviation headsets
10	59	M	II	Civilian	350	-	Dual-control
11	49	M	I	Military	10,000	-	Derogation
12	84	M	II	Civilian	567	yes	Derogation
13	59	M	I	Civilian	287	-	Derogation
14	58	M	I	Civilian	15,500	yes	ANR aviation headsets
15	57	M	II	Civilian	20	-	ANR aviation headsets
16	59	M	I	Civilian	15,700	-	Unfit to fly
17	54	M	II	Civilian	11,500	-	ANR aviation headsets
18	67	M	I	Civilian	34,800	-	ANR aviation headsets
19	53	M	I	Military	9850	-	Derogation
Mean	64				7840		

ANR: Active noise reduction.

DISCUSSION

The typical patient examined in the population analyzed in this study was primarily a Class II pilot, male, with an average age of 64 yr. This is in line with the characteristics of the French pilot population. Less than 10% of the pilots are women, and the retirement age of professional pilots in France is set at 60 yr.[9]

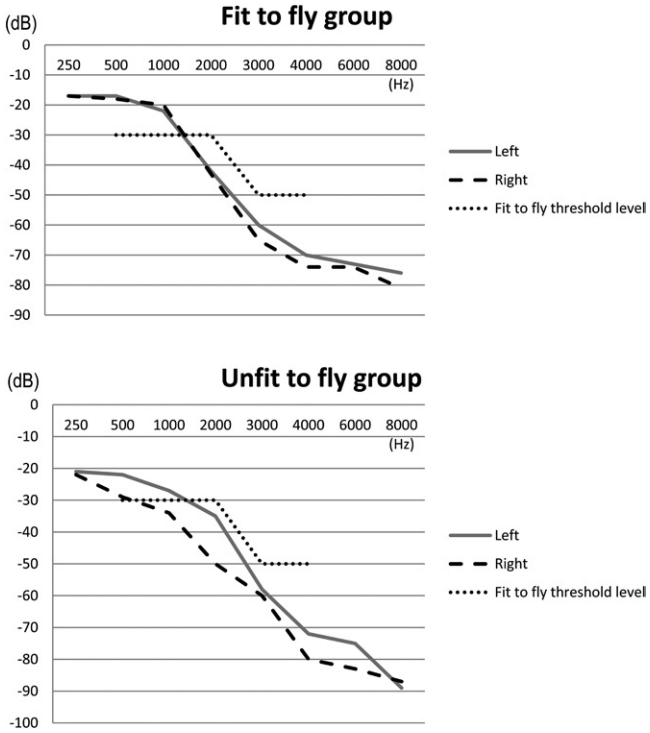

Fig. 3. Average audiogram of the right and left ears. The fit to fly threshold level corresponds to Class II pilots hearing performance standards (the lowest threshold level).

Fitness to fly is determined by French legislation. Audition needs to be minimally disturbed and is primarily assessed using pure-tone audiometry.[12,13] When tested using a pure-tone audiometer, the hearing loss at 250, 500, 1000, 2000, 3000, and 4000 Hz should not be more than the regulatory threshold in either ear (**Table IV**). If these standards are exceeded, even at a single frequency, the applicant must "demonstrate satisfactory functional hearing ability."[4] The regulatory standards of hearing in aircraft piloting do not take into account the natural evolution of hearing with age in France. The standards are clearly defined in terms of pure-tone audiometry. For remedies in fitness, the literature mentions the possibility of performing speech audiometry in noise, without giving precise criteria to determine the aptitude, leaving only the expertise of the examiner for judging flight fitness.[11] In our series, the maximum percentage of speech recognition and the slope of the curve for 50–100% speech recognition in speech audiometry in noise in the right ear were significantly better in the fit-to-fly group of pilots. Even if it was over the limits of statistical significance, there was a tendency of a better total slope of the curve for 50–100% speech recognition in speech audiometry in noise for the fit-to-fly group (Table III). These are the only parameters that apparently influenced the national ENT expert for his decisions about administering flight waivers for the pilots in the study population.

Presbycusis is a physiological phenomenon of aging marked by both peripheral (strial and neural disorders, as well as disorders of the outer and inner hair cells of the cochlea and of and of cochlear conduction) and central auditory processing lesions.[18] Kim et al. suggested that age degrades speech intelligibility in both quiet and noise. In addition, they indicated that the benefits from spatial separations of speech and noise, i.e., spatial release from masking, declined with age.[15] The slope of the curve for 50–100% speech recognition in speech audiometry

Table II. Speech Audiometry in Noise.

	FIT TO FLY	UNFIT TO FLY	*P*-VALUE, 95% CI
Right 50% speech recognition	74.5 dB	75.6 dB	$P = 0.85$, (-15.4765; 17.7265)
Left 50% speech recognition	71.7 dB	76.1 dB	$P = 0.98$, (-19.6866; 20.008)
Mean 50% speech recognition	75.23 dB	75.875 dB	$P = 0.88$, (-8.1737; 9.4594)
Right maximum percentage of speech recognition	92.9 dB	108 dB	***P* = 0.045,** (0.5118; 33.7739)
Left maximum percentage of speech recognition	87.5 dB	95 dB	$P = 0.14$, (-4.8427; 29.8427)
Mean maximum percentage of speech recognition	92.5 dB	101.25 dB	***P* = 0.04,** (0.3517; 17.1483)

in noise reflects the central integration capabilities of the sound signal. A lower slope (i.e., a high number tending toward 1) implies a greater reduction in the speed of signal-to-noise ratio processing.

Pure-tone audiometry does not seem to be a reliable predictive factor for a safe recovery of aviation activity. In our series, there was no difference between the two groups and no correlation between the depth of the mean hearing loss and the speech recognition thresholds in noise. The poor performance of speech understanding in noise by elderly individuals generally must consider the possible effect of central presbycusis.[14] Kim et al. found that the medial olivocochlear auditory efferent system declined with age in listeners with normal audiometric thresholds.[16] Giguère et al. used speech audiometry in noise to determine fitness for duty for hearing-impaired patients in a noisy environment.[8] Pure-tone audiometry was not found to be a significant prognostic factor of speech audiometry in noise. Tonal audiometry is a good reflection of attenuation secondary to peripheral impairment, whereas speech audiometry takes into account central integration.[6] Thus, in the literature, the pure-tone thresholds seem insufficient to decide on the fitness to fly or the auditory fitness for duty (for jobs such as law enforcement), which requires functional hearing abilities necessary to perform hearing-critical tasks.[19,22] Likewise, Casto et al. suggested that high levels of flight workload, especially in combination with poor communications signal quality, lead to deficits in flight performance and speech intelligibility, independent of the values of the pure-tone thresholds.[2] Speech audiometry in noise was even defined by Casto et al. as a "stress test" to establish a better assessment of the pilot's hearing in flight.[3]

Pure-tone audiometry, the numbers of flight hours and gender were not found to be significant prognostic factors of the outcomes, but our series was only composed of 19 subjects, which led to a lack of statistical power.

Class I pilots are subject to hearing performance standards with regular follow-up of these findings, which are required not only as consequences to ensure flight safety, but also as preventive measures due to the chronic noise exposure experienced by the pilots, which may cause or accelerate hearing loss.[7] The impact of chronic noise exposure in aircraft and helicopter pilots on hearing loss remains controversial, as it is not significant according to some authors,[21] or is indicative of the risk of early hearing loss for others.[1,6]

The French regulatory standards are therefore strict in order to reduce not only security risks but also the risk of occupational diseases and their costs. Military standards are stricter than civilian standards (Table IV). If we compare these standards to the ISO 7029 standards, taking into account age-related hearing loss, the regulatory thresholds can be exceeded for individuals at least 50 yr of age for military pilots and approximately 60 yr of age for civilian pilots: the median threshold for patients 50 yr of age at 4000 Hz is 36 dB, and that for patients 60 yr of age at 3000 Hz is 42 dB (**Fig. 4**).[10]

The regulatory thresholds are relatively close to the curve corresponding to a subject of 60 yr and are therefore frequently exceeded in these subjects. We used white noise at 65 dB and tested using Fournier's dissyllabic lists, all in headphones. This practice seemed to us more appropriate for testing pilots who use a helmet for radio transmissions in the cockpit and are subject to the permanent noise of the engine, which is similar to a white noise. However, the helmet cannot test patients with hearing aids. This does not allow us to take into account the possibility of hearing aid use by the pilot, which is achievable with helmets with active noise reduction for example.[17,20]

Free-field speech audiometry provides interesting possibilities for assessing the performance of current hearing aids, especially since one of the possible conditions for flight fitness waivers may be the wearing of active hearing aids. The development of a professional audiometric test could be performed in noise and would then address both the characteristics and utilization of the semantic content of the noise.

Among the 14 pilots who received waivers, 7 had restrictions on their flight fitness (Fig. 2). When compared with the results for pure-tone and speech audiometries, the decisions about their flight waivers in our series do not appear to be specific to presbycusis (there was a nonsignificant difference). These 7 patients already had restrictions when they were included in our series and we do not know the factors that influenced the decision-making. Depending on the type of activity (commercial or not), the type of aircraft or the motivation of the pilot, a workstation layout may allow the granting of a flight waiver. It is obvious that a Class I pilot will have stricter conditions than a Class II pilot still learning with a monitor permanently at his or her side for each flight. New restrictions (passenger limitations or flight authorization only without passengers, i.e., pilot only) appear to meet the demand of Class II pilots while at least respecting the standards of aptitude.

Table III. The Slope of the Curve 50–100% Speech Recognition in Speech Audiometry in Noise.

	FIT TO FLY	UNFIT TO FLY	*P*-VALUE, 95% CI
Right mean slope of the curve	0.37	0.64	***P* = 0.001,** (0.1226; 0.4182)
Right mean slope of the curve	0.32	0.4	$P = 0.59$, (-0.2915; 0.4444)
Total mean slope of the curve	0.34	0.50	***P* = 0.07,** (-0.0182; 0.3425)

Table IV. Civilian and Military Regulatory Standards of Hearing.

	250 Hz	500 Hz	1000 Hz	2000 Hz	3000 Hz	4000 Hz
Civilian Class I medical fitness certification	20	20	20	20	40	50
Military Class I medical fitness certification	20	20	20	20	30	30
Class II medical fitness certification	.	30	30	30	50	50

We propose a framework for determining whether a pilot is fit to fly with presbycusis under certain conditions and security guarantees, with or without restrictions, based on speech audiometry in noise. Audition is required to be minimally disturbed, and the achievement of a maximum percentage of speech recognition lower than 100 dB for both ears and a slope of the curve for 50–100% speech recognition less than 0.5 needs to be verified. These proposals are the responsibility of the expert via the waiver process. However, the current trend of aeronautical expertise is to expand and relax fitness standards. This tendency stems from the Anglo-Saxon philosophy, according to which "what does not hinder employment, should not prevent it" and for whom it is "discriminatory" to prevent an individual from exercising his profession for reasons of health. European and French regulations remain strict. This is why our study proposes, for the moment, these measures only with waivers.

CONCLUSION

Presbycusis is the most common cause of hearing loss in adults. Due to the increase in life expectancy and the aging of the population, the number of pilots suffering from age-related sensorineural hearing loss will increase, representing a risk for aviation activity. When a pilot is referred for presbycusis, his flight fitness is determined on the basis of his or her auditory performance and the follow-up examination of this finding. In our series, only 5 pilots out of 19 did not obtain waivers for flight fitness. The few published studies on the resumption of flight for patients who had presbycusis and our experience in France with similar waivers in commercial and military aviation suggest that under certain conditions and after relevant cochlear assessment, including the maximum percentage of speech recognition and the slope of the curve for 50–100% speech recognition in speech audiometry in noise, presbycusis may allow for a safe pursuit of aviation activity.

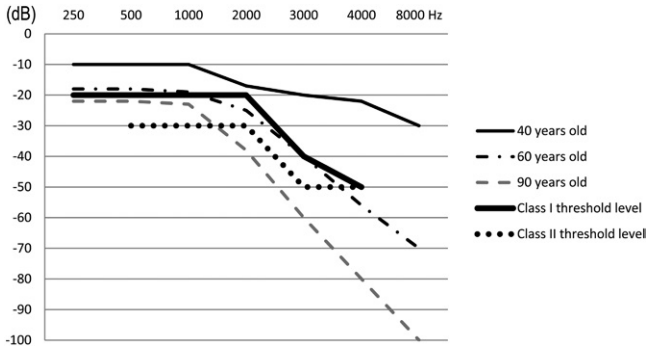

Fig. 4. Evolution of age-related hearing according to ISO 7029 standards and reporting with Class I and II medical fitness certification.

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