CASE REPORT

Ear and vestibular symptoms in train operators after sudden air pressure changes in trains

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SUMMARY

A healthy 31-year-old train operator presented to our occupational health clinic reporting ear aches, headaches, dizziness, unsteadiness and even slight tinnitus. These symptoms first appeared when the patient started operating from a new train cabin. He described a sudden pressure gradient, experienced on some parts of the trajectory, which might have caused these problems. Although the cabins were equipped with a pressure equalising device, this was usually switched off because of the device creating an uncomfortable feeling in the cabin. The literature describes sudden pressure gradients as possible factors for passenger discomfort.

Treatment with an antihistamine and nasal spray resulted in a subjective improvement after 3 months.

INVESTIGATIONS

Pressure waves that penetrate into the inner ear may inappropriately activate the oto-vestibular system, causing transient pressure-induced ear problems, such as alternobaric vertigo. Alternobaric vertigo is caused by unequal middle ear pressure due to a difference in Eustachian tube patency, stimulating the inner ear and thus provoking vertigo and/or unsteadiness. This has been well-documented in pilots and divers, and is considered a potential major factor in diving accidents.^{1–3}

In the type of train cabin where symptoms were most frequently reported, pressure variations were measured with a pressure transducer inside the cabin and one external transducer connected to a Pilot tube. Internal pressure fluctuations were measured when entering and exiting a tunnel and when passing other trains at a speed of 95 km/h; our data include measurements for when the pressurisation system was on and when it was off. Figures 1 and 2 show sudden pressure change measurements over time, both inside and outside the cabin, while driving in the usual trajectory.

Pressure changes have earlier been reported to give rise to ear discomfort in commuters and train operators.^{4,5} Ear discomfort has been described in passengers when trains passed through tunnels or were passing other trains at high speed. Schwanitz *et al.*,⁶ investigating the influence of pressure changes on the level of comfort experienced by train passengers, found that 14% of the passengers reported a level of discomfort ≥ 4 (7-point scale: 0='not at all uncomfortable' to 6='extremely uncomfortable') at a pressure change rate of 5 mBar/s (500 Pa/s). Rapid pressure variations occurred while entering and exiting tunnels or when passing trains travelling in the opposite direction.

Although the reported symptoms were more a matter of comfort on trains and hence no direct threat to health, they could produce disturbing feelings and unsteadiness, indirectly causing decreased alertness among train operators. Obviously, decreased alertness poses a safety risk, possibly leading to incidents or accidents. It is well known that human error contributes to the majority of incidents and accidents within complex systems, including railway systems.^{7,8}

OUTCOME AND FOLLOW-UP

All train operators working in east Flanders were subsequently followed up (N=502, average age

BACKGROUND

Few studies or reports exist on the effect of sudden atmospheric pressure changes on professional train operators. Our follow-up showed the existence of ear and vestibular symptoms among some operators when exposed to rapid changes in cabin pressure, although mostly under-reported (for fear of losing their job). Pressure-equalising devices were initially installed but never used (because of side effects: with the slightly increased pressure inside the cabin, operators felt enclosed and claustrophobic). Hence the importance of including occupational health physicians when introducing new technical features such as pressure control systems, as in this case. Occupational medical check-up should include awareness of the possible impact of these symptoms on operators and, indirectly, on passengers' safety.

CASE PRESENTATION

An otherwise healthy 31-year-old train operator, during his medical check-up, reported of regular symptoms of pressure on his ears, ear aches, headache and tinnitus. This occurred after he had started to operate from a new type of train cabin. He experienced sudden pressure changes in the cabin but could not equalise his ears (swallowing, slight Valsalva manoeuvre), resulting in pressure discomfort and pain in his ears, and even temporary tinnitus. There was neither hearing loss nor vertigo. He was an experienced operator with 5 years' experience. He was subsequently examined by an ear, nose and throat (ENT) consultant specialised in otology with full ENT examination including microtoscopia, rhinoscopia, rotational and caloric testing and nine-step tympanometry. These tympanometry findings showed a normal trace but with the existing symptoms and history a diagnosis of 'baro-challenged Eustachian tube dysfunction' was made.

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Figure 1 Pressure gradients measured when entering and exiting a tunnel, NMBS, Belgium. Pressures were measured in the cabin and on the exterior while the pressure system was ON (red) and again when it was OFF (blue).

40 years, 5 female operators). In a first step, operators were questioned and checked for ENT problems. If ENT problems or symptoms were observed, an in-depth interview took place in a second step. Also, a written summary of the specificities of the problems and trips involved was asked for and received.

A total of 11 of 502 persons (2%, average age 38 years, average seniority 14 years, no females) reported ear discomfort, in the majority of the cases combined with one or more symptoms of ear discomfort, headache, vertigo or tinnitus (table 1).

DISCUSSION

While overall air pressure changes in, for example, aircraft (typically around 20 kPa between ground level and cruising altitude level), are substantially greater than pressure changes inside trains, the average rate of pressure changes is much smaller in planes (about 0.03 kPa/s) than in trains.⁹ Although small, these pressure gradients have caused discomfort in passengers,^{4 5 9} especially when they are sudden, lasting only 1–2 s. The Union Internationale Des Chemins De Fer (UIC), therefore, in its code guidelines (651, 779–11), sets certain criteria to “protect driving crews against sudden and major air pressure fluctuations,” specifically a threshold of 4500 Pa/4 s for unsealed trains and ≤400 Pa/s in train cabins. Several technical measures can be taken to lower pressure gradients, such as reducing speed,

Figure 2 Pressure gradients measured while passing a train travelling in the opposite direction while the pressure system was ON (red) and again when it was OFF (blue).

Table 1 Reported symptoms

Symptoms	Number	Remarks
Ear discomfort	11/11	Ear aches or uncomfortable pressure on the ears, not able to clear
Headaches	3/11	Only slight headaches, disappearing after work
Vertigo	4/11	Slight vertigo—one person interrupted his trip due to unsteadiness
Tinnitus	2/11	Temporary

adapting tunnel designs or installing proper cabin pressure control systems and sealing train cabins.

In the literature, passenger discomfort is described mainly when entering tunnels;^{4 5 9} however, in this study, similar symptoms were reported by train operators not only while entering a tunnel but also when passing another train or driving under a bridge. Since these events happen frequently on consecutive days, this might lead to health problems other than simple discomfort. The percentage of people with ear discomfort was lower than the 14% reported earlier in the study by Schwanitz *et al.*⁶ In contrast to Schwanitz, who investigated train passengers, we focused on professional train operators, who might be more reluctant to report these symptoms. Indeed, it is difficult to convince train operators to report and undergo an interview or further examination, given the potential consequences for obtaining/losing a license to conduct the train, which may lead to underreporting.

Learning points

- Occupational health physicians must be aware that ear conditions can induce problems in professional train operators. A history of ear, nose and throat (ENT) problems at a younger age may predict otic barotrauma.¹⁰
- Questionnaires checking for obstructive Eustachian tube dysfunction (such as the 7-item Eustachian Tube Dysfunction Questionnaire)¹¹ or chronic otitis media (such as the 12-item Chronic Otitis Media Quality of Life measure)¹² could be used in pre-employment examinations and medical follow-up of train operators.
- High-risk operators (responding positively on these questionnaires) and operators experiencing these problems should be offered a more in-depth examination, including full ENT and vestibular system examinations.
- Alternation in cabins and/or trip trajectories may also help to avoid repetitive exposure when symptoms occur.
- Further studies are needed to investigate the prevalence of ENT-related problems within the train driving population, and the possible safety impact of these problems. We can expect that physical discomfort adversely affects the mental workload of train operators,¹³ affecting driver alertness, which could then cascade into a more severe incident.

Contributors HMAF was the main author, the co-authors contributed by reading, reviewing and editing the final manuscript.

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