POSSIBLE HEARING IMPLICATIONS OF DIABETES MELLITUS: A LITERATURE REVIEW

Possíveis implicações audiológicas do diabetes melito: uma revisão de literatura

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ABSTRACT

The purpose of this research is to review the literature to find the relation between diabetes mellitus, types I and II, and possible hearing disorders. According to the studies analyzed, was possible to conclude that there is a relation between hearing alteration and diabetes mellitus. It is believed there are several factors that contribute for this association, being needed more studies with more details to establish the true role of these factors.

KEYWORDS: Hearing Loss; Diabetes Mellitus; Audiology

INTRODUCTION

Diabetes mellitus is a metabolic disorder, in which there is uncontrolled sugar levels of the organism, affecting all sectors of the body. The pancreas does not produce insulin or produces inefficiently, failing to perform its biological purpose.

The main types of diabetes mellitus are type I and type II. In type I, there is an autoimmune destruction of beta pancreatic cells leading to insulin production inability, requiring insulin injections. Type II is characterized by affections to insulin action or secretion, with possible predominance of an event, usually being both present [1]. The metabolic control of type II diabetes is usually achieved with diet, physical exercises and/or concomitant use of oral hypoglycemic agents, insulin may be used in the treatment [1].

This study aims to analyze the relationship between diabetes mellitus, type I and II, and possible hearing disorders. This curiosity arose from the fact that audiological anamnesis, as applied in clinical audiology practice, questions patients about the presence of diseases like diabetes, thus expressing interest to investigate how such diseases affect hearing.

The prevalence of diabetes has increased in recent years, and often diabetic individuals present audiological symptoms such as hearing loss, tingling sensations and dizziness. Although several studies have been conducted, the association between hearing disorders and diabetes mellitus is still quite controversial, therefore this work aims to clarify possible hearing disorders found in individuals with this disease.

The study's development will specifically address issues involving general considerations about diabetes mellitus, including definition, types, and auditory behavior, such as common complaints and audiological findings.

The objective of this study is to perform a literature review to determine the relationship between diabetes mellitus, type I and II, and possible hearing disorders.

METHODS

In order to achieve the objectives of this study, research was conducted in electronic databases, namely: SciELO, MEDLINE and LILACS, and area books from the following combination of descriptors: diabetes mellitus X hearing loss, selecting the most significant studies in recent years.

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LITERATURE REVIEW

General considerations

Diabetes mellitus is a metabolic disease of multiple etiologies. It is characterized by chronic hyperglycemia resulting from disorders in the metabolism of carbohydrates, proteins and fats, due insufficient secretion function and/or insulin absence, as well as for defects of its action on insulin target tissues (liver, muscle and adipose tissues) [2].

In Brazil is quite high the incidence of chronic complications of diabetes. It is known that the number of individuals with the disease grows every year and it is estimated that half of these individuals are unaware of the diagnosis [3].

In this work will be focused possible audiological implications of diabetes type I and type II.

The type I diabetes mellitus is the most common form among children and adolescents, caused by partial or total destruction of pancreatic beta cells, resulting in progressive inability to produce insulin. This aggression is usually of the autoimmune nature, resulting from genetic and/or environmental processes. Insulin is always necessary in the treatment of type I diabetes mellitus and should be established as soon as the diagnosis is established [4,5].

The type II diabetes mellitus results from the action of insulin resistance mechanisms associated with a defect in hormone secretion, corresponding to the most prevalent form of diabetes worldwide [4]. These individuals still have some endogenous insulin, but their levels are insufficient to maintain normoglycemia due to resistance to its action [6]. It can happen at any age, but is most often diagnosed after age of 40 [4].

The main goal of the diabetic patient's treatment is prevention of chronic complications since the disease is not curable, but controllable. In a large number of individuals, especially children and adolescents, the diagnosis of diabetes is made in face of health complications, especially infections [3].

Complete clinical manifestation of diabetes is characterized by metabolic disorders, vascular and neuropathic complications [3].

One of the most consistent morphological aspects of diabetes mellitus is diffuse thickness of basal membrane, which also occurs in the vascular endothelium and is called diabetic microangiopathy. Its pathogenesis is still unclear, however it is clearly associated with hyperglycemia [7].

Other morphological alterations refer to the impairment of both motor nerves as the sensory nerves of lower extremities, characterized by damage to Schwann cells, degeneration of myelin and axon damage. The cause of neuropathy is still very controversial and may be related to diffuse microangiopathy that would affect nourishment of peripheral nerves [7].

Audiological implications

The association between hearing loss and diabetes mellitus (type I and type II) has been debated since it was first mentioned by Jordan in 1857, being subject of debate and remaining controversial to this day, despite numerous previous studies [8-11].

In 1864, it was identified the first scientific documentation connecting glucose metabolism disorders to inner ear diseases; observing the relation between sensorineural deafness and diabetes, thus establishing the link between hearing loss and hyperglycemia. Since then, several authors reported vestibular-cochlear secondary alterations to diabetes mellitus [11,12].

Among glucose metabolism disorders, diabetes mellitus is the affection most commonly related with auditory disorders [13], and the incidence of neurosensory hearing loss in patients with diabetes mellitus varies from 0% to 80% [11].

When it comes to diabetes mellitus, there are different opinions about the pathological affections caused in the auditory system. The hearing acuity may be compromised in patients with glucose metabolism alterations and insulin action alterations, regardless of age [14]. Researches have suggested a higher risk of hearing loss in diabetic patients, but other factors such as exposure to noise, ototoxic drugs and presbycusis, known to affect both glucose metabolism and cochlear function, make it difficult to establish this association [10]. Studies in humans are complicated for the variety of factors, in addition to the variations related to diabetes, such as duration of disease, metabolic control and the presence and degree of complications [10].

Ganança states that the metabolic changes that occur in diabetes mellitus, such as hyperglycemia, hyperinsulinemia and hypoglycemia, can cause various types of hearing loss and vestibular changes [15].

Patients with glucose metabolism disorders may experience auditory, vestibular or mixed symptoms. Dizziness may be of the rotatory kind, but it is not unusual to find complaints of instability, floating or a feeling of faint. Hearing complaints are varied and can be presented from fluctuating hearing loss to sensorineural hearing loss. Still occur tinnitus and aural feeling of fullness 14.

Glucose metabolism has great influence in the physiology of the inner ear and this stands out for its intense metabolic activity [13]. The underlying pathophysiology associated with diabetes and hearing

loss is subject to speculation. The main explanation would be the effect of diabetes in microvascular disease of the cochlea [9]. Unlike the retina, cochlea is virtually impossible to visually examine and its microvasculature is incorporated into the temporal bone, which can not be analyzed effectively, even under surgical conditions. Previous studies on cadavers have shown microvascular disease affecting the vascular groove, which is responsible for generating endolymph that serves as driving force for mechanical transduction of hair cells [16].

The involvement of the blood vessels supplying the inner ear and the changes occurring in the vascular striae in patients with diabetes mellitus are facts proven by several authors, who believe that such changes are strong evidence that diabetes mellitus may cause hearing loss [14].

Specifically in the auditory system, it may occur atrophy of spiral ganglion, degeneration of the eighth nerve myelin sheath, decrease on the number of nerve fibers in the spiral blade, or thickening of the capillary walls of the groove vascular and small arteries inside the ear canal [17].

Vascular and nerve tissues have predominant role in auditory function and any disease capable of causing damage its cells has the potential to negatively affect various hearing organs. In fact, the connection between hearing and diabetes seems likely if the blood supply to the cochlea and/or nerve centers in the auditory path, including the brain, are affected [18]. Both hypoglycaemia as hyperglycemia can alter the normal functioning of the cochlea, causing metabolic deafness through floating blood glucose, essential in the chemical constitution of endolymph [5].

The inner ear is especially sensitive to fluctuations in blood glucose and insulinemia. The vascular stria depends on constant glucose concentration and it is glycemic oscillation that triggers changes to balance as well as to hearing [19]. However, inner ear has no energy reserves in storage, which means that minor glycemic variations influence its function, causing alterations [13].

Metabolic changes in the inner ear cause a potassium displacement from the endolymph to the perilymph, and sodium displacement in the opposite direction. This mechanism would cause vertigo, tinnitus, hearing loss and aural feeling of fullness [19]. It is also observed that there is a reduction of hair cells and a smaller oxygenation on them, due to these vascular abnormalities of the inner ear [20].

There is controversy regarding the etiology and pathogenesis of hearing loss. Some researchers support that it occurs due to neuropathy; others attribute the disease to angiopathy; and another group claim it's a combination of the two [21,22]. But there are those who understand that diabetes mellitus and hearing loss could be an integral part of a genetic syndrome and not dependent upon each other [21].

Angiopathy and neuropathy are diabetes complications, well recognized, but not fully understood, and are considered important factors responsible for vestibulocochlear manifestations [21]. It is believed that metabolic factors, vascular abnormalities and other mechanisms besides the peripheral nerves' vulnerability, could affect the inner ear and/or the eighth nerve and cause decreased hearing [8].

Diabetic angiopathy has been characterized by endothelial proliferation, glycoproteins accumulation in the intima and thickening of the basal membrane of capillaries and small blood vessels. Angiopathy may occur both directly by interfering with the blood supply to the cochlea by reducing transport through the thickened walls of capillaries, and indirectly, by reducing the flow in a narrowed vasculature, or even by secondary degeneration of the eighth cranial nerve [23]. Several authors have previously suggested that microangiopathy could be responsible for functional changes in the inner ear associated with diabetes mellitus [10]. There appears to be a relationship between hearing loss severity and disease progression, and this may be due to microangiopathic disease in the inner ear [22].

Diabetic neuropathy, one of the main complications that appear from time of diabetes mellitus chronic evolution, is characterized by progressive degeneration of nerve fibers' axons [24]. The main electrophysiological change in diabetic neuropathy seems to be a decrease in the amplitude of sensory and motor responses in peripheral nerves. However, it also seems to exist a demyelinating action by hyperglycemia, which leads to a decrease in nerve conduction velocity [25].

Regardless of the etiology and pathogenesis of hearing loss, it can be noted that several studies of auditory function in diabetic patients showed that hearing loss attributed to diabetes mellitus (type I and type II) is usually of the progressive bilateral neurosensorial type, predominantly in high frequencies [13, 14, 26], especially in the elderly [13,26]. Another study also mentions the possibility of an early neurosensorial hearing loss [10].

Several researches revealed hearing loss, sensorineural in most cases, with a predominance of light to moderate degree and affecting higher frequencies [27]. Hearing loss present at higher frequencies could be explained by the fact that the basal region of the cochlea is more vascularized, which predisposes it to more obvious effects of vascular damage [28]. The hyperglycemia, in turn, could be further present in this region and therefore,

its effects would be greater than those observed in other regions of the cochlea [29].

Perhaps, as seen in aging and ototoxic subjects, the basal or high frequency region in the cochlea is susceptible to certain diseases, such as diabetes. Although routine clinical tests usually run only in the frequencies of speech, when they identify sensitivity beyond this region (at higher frequencies), we obtain a more complete picture of cochlear status, which may indicate declining hearing in the high frequencies [10].

In a study by Maia and Campos, there is no consensus regarding audiological and histopathological aspects of type I diabetes mellitus [21]. In this study, there were three cases (10.0%) of sensorineural hearing loss, in which one case (3.3 %) was of flat bilateral moderate sensorineural hearing loss kind and two cases (6.6%) were of descending bilateral moderate sensorineural hearing loss.

Conventional audiometric tests are not sensitive enough to detect the earliest stages of sensorineural hearing loss. For this, it can be used electrophysiological methods and otoacoustic emissions [11].

The otoacoustic emissions test is a physiological objective test of outer hair cells. A study indicates that the distortion product otoacoustic emissions can detect early hearing loss in diabetic patients because they are more sensitive than routine behavioral audiometry to detect cochlear dysfunction in these patients [30]. A smaller amplitude of distortion product otoacoustic emissions of 4.0 kHz was reported by Lisowska et.al [11].

Several studies have revealed alterations in auditory brainstem evoked potential in individuals with diabetes mellitus showing a prolonged latency of waves III and V [11, 30]. Bayazit et al. also reported in its research on 59 diabetic patients an increase in latency of the main components of the responses of the brain stem [31].

In order to investigate the relationship between diabetes mellitus and hearing, another study used the P300 cognitive potential, which has been used as an objective procedure to assess cerebral cognitive function. The results of this study showed that the decrease in blood glucose level in diabetic individual leads to increased latency and decreased amplitude of the P300 component, suggesting a dysfunction in the central auditory system. Considering that the nervous tissue is glucose-dependent, i.e., dependent on a stable level of glucose in ideal situations, extended periods of hypoglycemia episodes can lead to significant individual neurological alterations [1].

Other findings related to diabetes and hearing loss indicate that diabetes can be considered one of the causes of idiopathic sudden hearing loss [32,33] since diabetes mellitus is known can cause microvascular damage, as well as other microcirculation disorders involving sudden increase of blood viscosity and thromboembolic episodes [32]. According to Weng et al., diabetic patients with idiopathic sudden hearing loss tend to be predominantly male, elderly and have a high prevalence of hypertension and hyperlipidemia [33].

In relation to the vestibular system, it is experimentally shown that Labyrinthic structures, and especially the vascular groove, present intense metabolic activity and thus depends on constant and adequate supply of oxygen and glucose [34]. Klagenberg et al. observed the prevalence of changes in the peripheral vestibular system and the peripheral vestibular deficit syndrome [35]. This result is consistent with other studies that also found changes in the vestibular exam [36,37].

It is also known that the metabolic disorders can affect the homeostasis of the vestibular organ faster than the auditory portion [38]. Gawron et al. noted that the detection of disorders present in the central nervous system in patients with diabetes mellitus seems to be more sensitive through vestibular assessment than by audiological evaluation. In the same study, the authors found that auditory tests and measures of acoustic impedance were within the normal range, although most of them had central change in the vestibular assessment [38].

In contrast, findings from Biurrun et al., point out that patients with newly diagnosed diabetes mellitus showed no abnormality in vestibular assessment. This led to consider that the effect of diabetes on vestibular function could possibly be mediated with diabetic complications such as neuropathy and angiopathy, which are absent at disease onset [36].

However, other authors have reported minimal cellular changes and functional impairment of the central labyrinthic pathways as complications of initial diabetes mellitus, with no relation to neuropathy or microangiopathy [9]. This is probably because the labyrinth is particularly sensitive to small variations in glucose and insulin plasma levels, and evidenced by the presence of insulin receptors in the endolymphatic sac [39].

As previously mentioned, it is known that patients with diabetes mellitus often show symptoms such as dizziness, tinnitus and hearing loss. It is called attention to the difficulty in distinguishing hearing loss in diabetics from senile hearing loss, in non-diabetic individuals. Some studies indicate that a reduction in auditory acuity, which is similar to that shown in presbycusis, is greater than expected for

the age, in elderly and diabetic patients [10]. After age 60, the difference in hearing loss between diabetics and non-diabetics was reduced [10].

However, other studies have reported that hearing loss found in diabetes does not follow a pattern similar to presbycusis, due to the fact that the distribution of frequencies is more linear [40].

To the present time, we have not found specific studies that showed data related to speech recognition tests in diabetic patients. Some authors refer only that changes in brain cells on some diabetics can result in slower processing of complex sounds, such as of speech [18].

CONCLUSION

According to the analyzed studies, we can conclude that there is a relation between hearing disorders and diabetes mellitus. We also believe that there are a number of contributing factors to such an association, and more discerning studies are required to establish the true role of these factors.

Considering the above, it can be noticed that people with diabetes mellitus are more likely to have hearing loss. Thus, this possibility should be investigated by health professionals working with diabetic patients so that such patients might benefit if audiologically monitored.

RESUMO

O objetivo deste trabalho é realizar uma revisão bibliográfica procurando analisar a relação entre diabetes melito, tipos I e II, e as possíveis alterações audiológicas. De acordo com os estudos analisados, pode-se concluir que existe relação entre alterações audiológicas e diabetes melito. Acredita-se ainda que há uma série de fatores que contribuem para tal associação, sendo necessários estudos mais criteriosos que estabeleçam o verdadeiro papel desses fatores.

DESCRITORES: Perda Auditiva; Diabetes Mellitus; Audiologia

REFERENCES

1. Alvarenga KF, Duarte JL, Silva DPC, Agostinho-Pesse RS, Negrato CA, Costa AO. Potencial cognitivo P300 em indivíduos com diabetes mellitus. Rev. Bras. Otorrinolaringol. 2005;71(2):202-7.

2. Lebowitz HE. Goals of treatment. In: Lebowitz HE, editor. Therapy for diabetes mellitus and related disorders. 3ed. Alexandria: American Diabetes Association; 1998. p.1-4.

3. Chacra AR. Diabetes mellitus. In: Prado FC, Ramos JA, Borges DR, Rothschild HA. Tratado de Atualização Terapêutica. 20ed. São Paulo: Câmara Publicadora do Livro; 2001. p.375-89.

4. Della MT. Nem toda criança diabética é tipo 1. J. Pediatr. 2007;83(5): 178-83.

5. Pallardo Sánchez LF. Alteraciones del metabolismo de los hidratos de carbono. In: Rodés Teixidor J, Guardiã Massó J. Medicina interna. Barcelona: Masson; 1997.p.2667-707.

6. Silva FML, Silva MMML. Diabetes mellitus do tipo II nos dias atuais. J Bras Med. 2005;88(1/2):13-22.

7. Robbins SL, Cotran RS, Kumar V. Pathologic Basis of disease. 3ed. Philadelphia: W.B. Sauders Co.; 1991.

8. Fowler PD, Jones NS. Diabetes and hearing loss. Clinical Otorrinolaringol. & allied sciences. 1999;24(1):3-8.

9. Lisowska G, Namyslowski G, Morawski K, Strojek K. Cochlear dysfunction and diabetic microangiopathy. Scand Audiol Suppl. 2001;52:199-203.

10. Vaughan N; James K; McDermott D; Griest S; Fausti S. A 5-year prospective study of diabetes and hearing loss in a veteran population. Otol Neurotol. 2006;27(1):37-43.

11. Lisowska G, Namyslowski G, Morawski K Strojek K. Early identification of hearing impairment in patients with type 1 diabetes mellitus. Otol Neurotol. 2001;22(3):316-20.

12. Doroszewska G, Kazmierczak H. Hyperinsulinemia in vertigo, tinnitus and hearing loss. Otolaryngol Pol. 2002;56(1):57-62.

13. Albernaz PLM. Doenças metabólicas da orelha interna. RBM - Otorrinolaringologia. 1995;1:18-22.

14. Marchiori LLM, Gibrin PCD. Diabetes mellitus: prevalência de alterações auditivas. Arq Bras Endocrinol Metab. 2003;47(1):82-6.

15. Ganança MM & Fukuda Y. Otorrinolaringologia. Rio de Janeiro: Guanabara Koogan; 1995.

16. Fukushima H, Cureoglu S, Schachern PA, Kusunoki T, Oktay MF, Fukushima N, et al. Cochlear changes in patients with type 1 diabetes mellitus. Otolaryngol Head Neck Surg. 2005;133:100-6.

17. Jerger S, Jerger J. Diabetes Mellitus. In: Jerger S, Jerger J. Alterações auditivas: Um manual para avaliação clínica. Ed. Atheneu;1998. p.35-9.

18. Vaughan N, McDermott D. Diabetes and hearing loss: exploring connections. Hear Health. 2003;19(3): 37-43.

19. Ferreira Junior CA, Guimarães RES, Becker HMG, Silva CD, Gonçalves TML, Crosara PFTB et al. Avaliação metabólica do paciente com labirintopatia. Arq Otorrinolaringol. 2000;4:28-32.

20. Albernaz PLM, Ganança MM, Fukuda Y, Munhoz MSL. Otorrinolaringologia para o clínico geral. São Paulo: BYK; 1997.

21. Maia CAS, Campos CAH. Diabetes Mellitus como causa de perda auditiva. Rev Bras Otorrinolaringol. 2005;71(2):208-14.

22. Kakarlapudi V, Sawyer R, Staecker H. The effect of diabetes on sensorineural hearing loss. OtolNeurotol. 2003;24(3):382-6.

23. Taylor IG, Irwin J. Some audiological aspects of diabetes mellitus. J Laringol Otol. 1978;92(2):99-113.

24. Partanen J, Niskanen L, Lehtinen J, Mervaala E, Siitonen O, Uusitupa M. Natural history of peripheral neuropathy in patients with non-insulin-dependent diabetes mellitus. N Eng J Med.1995;333:89-94.

25. Herrmann DN, Ferguson ML, Logigian EL. Conduction slowing in diabetic distal polyneuropathy. Muscle Nerve. 2002;26:232-7.

26. Santos TM, Russo ICP. A prática da audiologia clínica. 6ed. São Paulo: Cortez; 2007.

27. Ferreira JM, Sampaio FMO, Coelho JMS, Almeida NMGS. Perfil audiológico de pacientes com diabetes mellitus tipo II. Rev. Soc. Bras. Fonoaudiol. 2007;12(4):292-7.

28. Kasemsuwan L, Sriwanyong S, Krittiyawong S, et al.Hearing in young diabetic patients. J Med Assoc Thai. 2001;84:1389-94.

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29. Reis HG, Tschiedel B, Broto JP. Limiares audiométricos de altas frequências em pacientes com diabetes mellitus insulino-dependente. Scientia Medica Porto Alegre: PUCRS. 2006;16(1):16-22.

30. Ottaviani F; Dozio N; Neglia CB; Riccio S; Scavini M. Absence of otoacoustic emissions in insulin-dependent diabetic patients: is there evidence for diabetic cochleopathy?. J Diabetes Complications. 2002;16(5):338-43.

31. Bayazit Y, Yilmaz M, Kepekci Y, Mumbuc S, Kanlikama M. Use of the auditory brainstem response testing in the clinical evaluation of the patients with diabetes mellitus. J Neurol Sci. 2000;181:29–32.

32. Fukui M, Kitagawa Y, Nakamura N, Kadono M, Mogami S, Ohnishi M et al. Idiopathic sudden hearing loss in patients with type 2 diabetes. Diabetes Res Clin Pract. 2004;63(3):205-11.

33. Weng SF; Chen YS; Hsu CJ; Tseng FY. Clinical features of sudden sensorineural hearing loss in diabetic patients. Laryngoscope. 2005; 115(9):1676-80.

34. Rubin W, Brookler KH. Etiologic diagnosis and treatment. In: Dizziness: Etiological approach to management. New York: Thieme Publishers; 1991. p. 72-87.

35. Klagenberg KF, Zeigelboim BS, Jurkiewicz AL, Martins-Bassetto J. Manifestações vestibulococleares em pacientes com diabetes melito tipo I. Rev. Bras. Otorrinolaringol. 2007;73(3):353-8.

36. Biurrun O, Ferrer JP, Lorente J, España R, Gomis R, Traserra J. Asymptomatic eletronystagmographic abnormalities in patients with type I diabetes mellitus. ORL J Otorhinolaryngol Relat Spec. 1991;53(6):335-8.

37. Scherer LP, Lobo MB. Pesquisa do nistagmo/vertigem de posição e avaliação eletronistagmográfica em um grupo de indivíduos portadores de diabetes mellitus tipo I. Rev Bras Otorinolaringol. 2002;68(3)355-60.

38. Gawron W, Pospiech L, Orendorz-Fraczkowska K, Noczynska A. Are there any disturbances in vestibular organ of children and young adults with type I diabetes? Diabetologia. 2002;45(5):728-34.

39. Knight LC, Saeed SR, Hradek GT, Schindler RA. Insulin receptors on the endolynphatic sac: an autoradiographic study. Laryngoscope. 1995;105(6):635-8.

40. Dall'Igna C, Batista LRP, Siqueira MK. Patogênese da disacusia neurossensorial em diabetes mellitus. Rev Bras Otorrinolaringol. 2000;66(2):155-8.