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Main Article

Effects of open heart surgery on hearing thresholds measured by high frequency audiometry

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Abstract

Background: The aim of this study was to investigate the differences between pre- and post-operative hearing thresholds, measured by high frequency audiometry, in patients undergoing open heart surgery.

Materials and methods: Pre- and post-operative audiometric assessments were performed in 20 patients undergoing open heart surgery. Pure tone audiometry testing was performed at 500, 1000, 2000, 3000, 4000, 6000, 8000, 10 000, 12 000 and 14 000 Hz. We also evaluated: patients' clinical parameters (i.e. age, sex, diabetes mellitus, hypertension, hypercholesterolaemia, history of myocardial infarction, and whether undergoing coronary artery bypass surgery or valve surgery); various operative details (operative temperatures, cardiopulmonary bypass time and cross-clamp time); and post-operative clinical progress and its effect on hearing loss.

Results: Patients' pre- and post-operative pure tone audiometric results were significantly different at some frequencies ($p < 0.05$). In addition, there was a significant impact of hypertension, hypercholesterolaemia, history of myocardial infarction and cross-clamp time.

Conclusions: This study shows that open heart surgery using cardiopulmonary bypass can lead to significant post-operative changes in hearing levels at some frequencies. Some additional patient parameters may influence this process. It seems possible that the risk of such hearing loss could be reduced; further studies may be able to define the significance of patients' concomitant disorders.

Key words: Sensorineural Deafness; Cardio-Pulmonary Bypass; Audiometry

Introduction

Coronary artery bypass grafting has been performed for 40 years. The incidence of severe hearing loss following coronary artery bypass surgery has been estimated as 0.1 per cent.[1] The first reported case of such hearing loss was presented by Arenberg *et al.* in 1972.[1] Sudden sensorineural hearing loss (SNHL) is a well recognised phenomenon that has been attributed to a variety of aetiologies. Several aetiologies have been suggested to explain SNHL following open heart surgery, including: thromboembolic phenomena; hypotension or perfusion failure; hypothermia; ototoxic drug use; and related central nervous system injury (such as stroke). However, no proven pathogenesis has yet been established.

The aim of this study was to investigate hearing changes following open cardiac surgery, using high frequency audiometry, and to determine which clinical and operative factors were related to SNHL.

Materials and methods

Between August and September 2004, 30 patients underwent open cardiac surgery, 20 of whom were capable of completing pre- and post-operative questionnaires. These questionnaires specifically enquired about any changes in patients' hearing, and about the presence of tinnitus. Audiometric testing was performed on post-operative days six to 15. Consequently, 40 ears of 20 patients were included in the study. Patients without a past medical history of hearing problems, ototoxic drug use or neurological disease were examined prior to and following their coronary bypass procedure, and audiometric assessment was also performed. Patients with a history of hearing problems, ototoxic drug use or neurological disease, or of post-operative neurological complications, were excluded from the study. Similar anaesthetic agents were used on all patients, and each anaesthetic parameter was examined.

Audiometry

Audiometric assessment was performed within the Ankara Numune Education and Research Hospital otolaryngology department, pre- and post-operatively. Pure tone audiometry findings were obtained for the frequencies of 500, 1000, 2000,

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4000 and 8000 Hz, and also for the following high frequencies: 10 000, 12 000 and 14 000 Hz. All audiometry was performed by the same person using an Interacoustic AC 40 audiometer (İnteracoustic Company, Assens, Denmark), which was calibrated periodically.

Audiometric measurements were compared both pre- and post-operatively, taking into account the following patient parameters: age; sex; presence or absence of diabetes mellitus, hypertension and high cholesterol level; history of myocardial infarction; and presence of coronary artery or valve disease. When comparing pre- and post-operative audiometric results, the following surgical parameters were also noted: type of procedure; cardiopulmonary bypass time; cross-clamping time; and operation temperature (patient's rectal temperature).

Statistics

Data were analysed using non-parametric statistics. Paired comparisons within a group were analysed with the Wilcoxon signed rank test. A p value of <0.05 (two-tailed) was considered significant. The Statistical Package for the Social Sciences version 11.0 for Windows software (SPSS Inc, Chicago, Illinois, USA) was used for statistical analysis.

Results

Twenty patients completed the study. Twenty-five per cent (five of 20) of the patients were female and 75 per cent (15/20) were male. The mean age was 48.8 years (range, 42 to 55 years). Thirty per cent (six of 20) of the patients had hypertension, 20 per cent (four of 20) had diabetes mellitus, 25 per cent (five of 20) had hypercholesterolaemia, 25 per cent (five of 20) had a history of myocardial infarction, 55 per cent (11/20) had coronary artery disease and 45 per cent (nine of 20) had cardiac valve disease.

The mean duration of total cardiac bypass time was 66.45 minutes (standard deviation (SD) 23.3), the mean cross-clamp time was 40.5 minutes (SD 16.8) and the mean operation temperature (patient's rectal temperature) was 30.3°C. Patients' audiograms were analysed to assess pre- and post-operative differences, for each frequency (Figure 1). The mean pre- and post-operative hearing values, for right and left ears, were also evaluated for each frequency (Figures 2 and 3).

For the right ear, differences between pre- and post-operative hearing values were statically significant at 500, 1000, 8000, 10 000, 12 000 and 14 000 Hz frequencies ($p < 0.05$). For the left ear, differences between pre- and post-operative mean hearing values were statistically significant at 1000, 8000, 10 000 and 12 000 Hz frequencies ($p < 0.05$).

Risk factors for both the individual patients and the surgical procedures were compared with respect to significant hearing loss in each frequency. The following significant correlations were found: between hearing loss and the presence of hypercholesterolaemia, at 8000 Hz ($p = 0.03$) and 10 000 Hz ($p = 0.02$) frequencies; between hearing loss and a history of myocardial infarction, at 10 000 Hz ($p = 0.05$) and 12 000 Hz ($p = 0.04$); between hearing loss and the presence of hypertension, at 8000 Hz ($p = 0.03$) and 10 000 Hz ($p = 0.01$); and also between an increased cross-clamp time and hearing loss at 500 Hz ($p = 0.03$). We found no differences between patients undergoing coronary artery bypass surgery and those undergoing cardiac valve replacement.

When total mean pre- and post-operative hearing thresholds of the right and left ears were compared for each separate frequency, significant differences were found at 500, 1000, 8000, 10 000, 12 000 and 14 000 Hz frequencies ($p < 0.05$) (Figure 1).

Discussion

In the general population, the incidence of sudden SNHL is reported as approximately one in 5000.

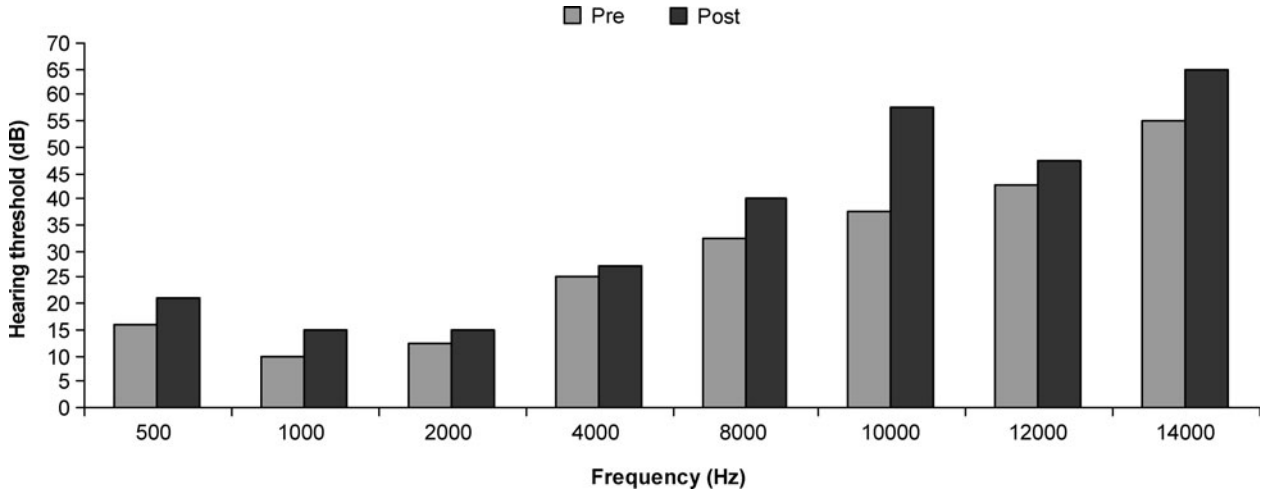

FIG. 1

Distribution of median pre- and post-operative audiometric hearing thresholds, by frequency. Pre = mean pre-operative values for 40 ears; post = mean post-operative values for 40 ears

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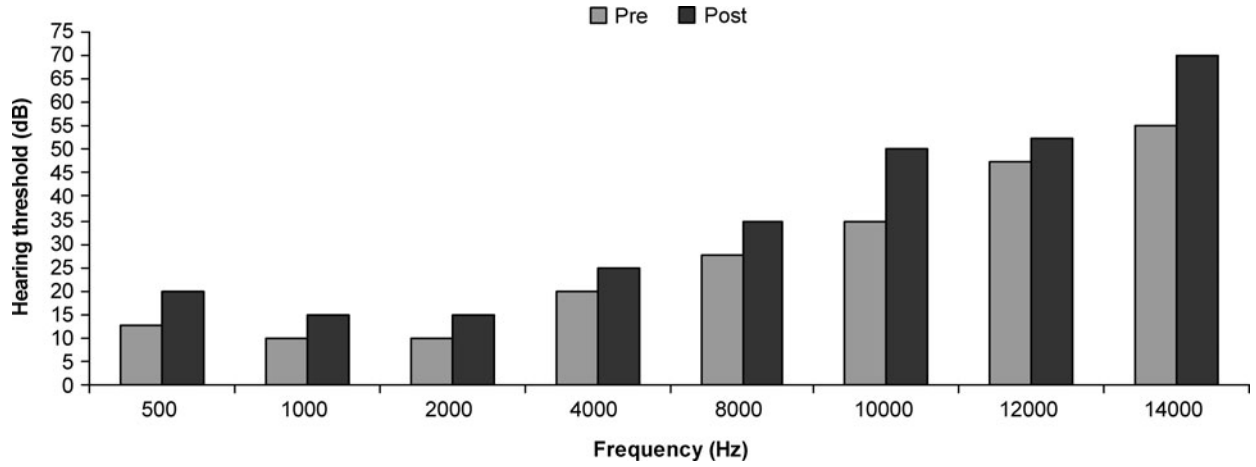

FIG. 2
Distribution of median hearing thresholds for the right ears, by frequency. Pre = pre-operative values; post = post-operative values

The main aetiological factors are inflamatory vascular, metabolic, biochemical, traumatic, tympanic membrane rupture and idiopathic causes.[2]

Sensorineural hearing loss following open cardiac surgery was first described by Arenberg *et al.* in 1972.[1] In 1975, Wright and Saunders reported a similar case.[3] A large, retrospective case analysis including 7000 patients was carried out by Plasse *et al.* They reported the incidence of SNHL after cardiopulmonary bypass surgery as being one in 1000.[4]

Shapiro *et al.* categorised patients suffering hearing loss following cardiac surgery into three groups: those with no change; those with slight changes; and those with average hearing deficits of more than 10 dB. Hearing loss of less than 10 dB was difficult to recognise because of poor cooperation and concentration. However, in Shapiro and colleagues' series of 68 patients, 13.2 per cent showed hearing loss at high frequencies after cardiopulmonary bypass surgery.[5]

The incidence of complications following open cardiac surgery is high; surgical complications constitute 50 per cent, and cerebral complications 2–5 per cent. Hearing loss is observed as a post-operative complication in 0.01 per cent of patients.[6] Ness *et al.* compared the incidence of SNHL following coronary bypass surgery (0.14 per cent) with that seen in a normal population (0.02 per cent).[7] These authors postulated that the higher incidence of SNHL seen after cardiac surgery was due to risk factors in some patients (diabetes mellitus, hypertension, hypercholesterolaemia, etc), complications due to surgery and the use of ototoxic drugs.[7] In our study, patients who suffered significant surgical complications and those using ototoxic drugs were excluded from analysis. Furthermore, when risk factors attributed to patients and to the surgical procedure were analysed separately, some risk factors were thought to be causative for SNHL. There are four main theories explaining SNHL after open cardiac surgery: microemboli; intra-operative hypotension or perfusion abnormality; hypercoagulability; and use of ototoxic drugs.[6–8]

Some animal studies have shown that thrombosis, emboli or spasm affecting the labyrinthine artery

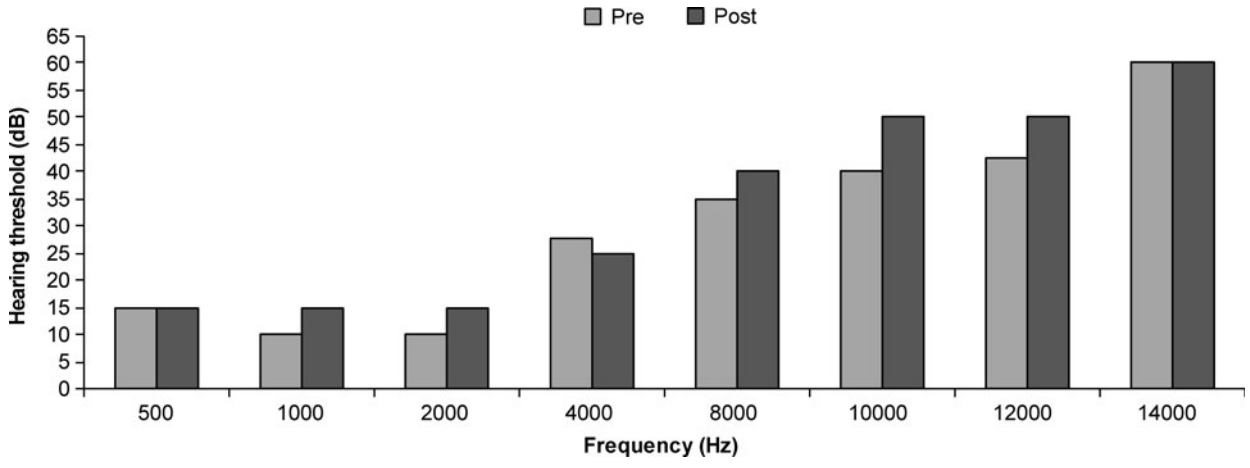

FIG. 3
Distribution of median hearing thresholds for the left ears, by frequency. Pre = pre-operative values; post = post-operative values

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may cause SNHL.[9,10] This makes temporal bone histological studies mandatory in order to clarify the aetiology of SNHL following cardiac surgery.

- **The aim of this study was to investigate changes in hearing, using high frequency audiometry, following open cardiac surgery**
- **Open heart surgery using cardiopulmonary bypass leads to significant post-operative changes in hearing levels at some frequencies**
- **The presence of hypertension or hypercholesterolaemia, a history of myocardial infarction, and cross-clamp time were found to significantly influence hearing levels following cardiac surgery**
- **Further studies are required to investigate the aetiology of hearing loss following cardiac surgery**

Phillipps and Thornton, in their study of 20 patients undergoing cardiac surgery, described post-operative SNHL mainly at higher frequencies.[11] Any pathology affecting the cochlea and the distal portion of the VIIIth cranial nerve will cause more of a disturbance to the basal portion of the cochlea. Therefore, high frequency audiometry is an effective tool in demonstrating these pathological changes.[12] Our findings also revealed that hearing loss was more frequently present at higher frequencies.

In 1967, Jaffe first described SNHL in 14 patients following non-otological, non-cardiac surgical procedures performed under general anaesthesia.[13] Similar cases have been reported in the literature.[6] All our patients underwent similar anaesthetic procedures; therefore, the effect of general anaesthesia in itself was minimised.

Conclusion

Our findings demonstrated that SNHL occurs after cardiac surgery, especially at higher frequencies. It is thought that some risk factors may be causative for such SNHL, but a definite aetiology could not be clarified. However, we believe that more extended patient investigations and post-mortem histopathological studies may be able to identify the aetiological factors responsible.

References

1 Arenberg IK, Allen GW, DeBoer A. Sudden deafness immediately following cardiopulmonary bypass. *J Laryngol Otol* 1972;**86**:73–7
2 Byl FM. Sudden hearing loss: eight years' experiences and suggested prognostic table. *Laryngoscope* 1984;**94**:647–61
3 Wright JLW, Saunders SH. Sudden deafness following cardiopulmonary bypass surgery. *J Laryngol Otol* 1975;**89**:757–9
4 Plasse HM, Mittleman M, Frost JO. Unilateral sudden hearing loss after open heart surgery: a detailed study of seven cases. *Laryngoscope* 1981;**91**:101–9
5 Shapiro MJ, Purn JM, Raskin C. A study of the effect of cardiopulmonary bypass surgery on auditory function. *Laryngoscope* 1981;**91**:2046–52
6 Young In Min, Mahta GK, Lowry LD. Unilateral sudden hearing loss with complete recovery following cardiopulmonary bypass surgery. *Yonsei Med J* 1987;**28**:152–6
7 Ness JA, Stankiewicz JA, Kaniff T, Pifarre R, Allegretti J. Sensorineural hearing loss associated with aortocoronary bypass surgery: a prospective analysis. *Laryngoscope* 1993;**103**:589–93
8 Brownson JB, Stroed MH, Carver WF. Extracorporeal cardiopulmonary bypass and hearing. *Laryngoscope* 1971;**91**:179–82
9 Alford BR, Shaver EF, Rosenberg JJ. Physiologic and histopathologic effect of microembolism of the internal auditory artery. *Ann Otol Rhinol Laryngol* 1965;**74**:728–48
10 Belal A Jr. Pathology of vascular sensorhineral hearing impairment. *Laryngoscope* 1980;**90**:1831–9
11 Phillipps JJ, Thornton ARD. Audiometric changes in patients undergoing coronary artery bypass surgery. *Br J Audiol* 1996;**30**:19–25
12 Belgin E, Böke B, Dalgıç G. The findings of high frequency odiometric results in with various ages patients. *KBB Bulteni* 1994;**2**;40–4
13 Jaffe BF. Sudden deafness: an otologic emergency. *Arch Otolaryngol* 1967;**86**:81–6

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