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Sensorineural hearing loss in sickle cell anaemia – a United Kingdom study

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Abstract

Sensorineural hearing loss (SNHL) has been a well-documented complication of sickle cell disease in the literature from West Africa, West Indies, United States of America and the Middle East. We present a study of 52 patients with homozygous sickle cell disease and 36 control patients with haemoglobin genotype AA, matched for age and sex. Seven patients with sickle cell disease (13.5 per cent) were found to have sensorineural hearing loss i.e. >20 dB at two or more frequencies, while all the patients in the control group had normal hearing ($p<0.05$).

Our study shows the incidence of SNHL in the UK to be similar to that reported in the USA and much lower than that found in malaria endemic areas of the tropics.

We highlight the factors which we consider responsible for these differences and suggest that the crucial period in the development of SNHL in sickle cell disease may be intra-uterine or during the first few years of life. All sickle cell patients should be encouraged to have regular hearing assessment.

Key words: Hearing loss, sensorineural; Sickle cell disease

Introduction

Sickle cell disease is a common hereditary haematological disorder of haemoglobin which occurs mainly in the Negroid race in Africa, the black people of North and South America and the West Indies. There are variants of the disorder in certain localities in Greece, southern Italy, Turkey, the Middle East and India. Even though the principal disorder is haemolytic anaemia, the manifestation is often multisystemic (Serjeant, 1985). There is a consensus in the various audiological studies (Todd *et al.*, 1973; Friedman *et al*, 1980; Odetoyinbo and Adekile, 1987) that patients with sickle cell anaemia have a much higher incidence of sensorineural hearing loss than the rest of the population.

The aim of our study was to establish the incidence of SNHL in the UK, identify the most vulnerable period of occurrence and find ways of contributing towards prevention and rehabilitation.

Various hypotheses have been proposed about the pathogenesis of sensorineural hearing loss in sickle cell disease. Morgenstein and Manace (1969), first suggested compression of the internal auditory canal by expansion of the marrow in the petrous temporal bone and also suggested damage to the stria vascularis and hair cells from hypoxia. Serjeant *et al.* (1975) could not find any radiological evidence to confirm the first claim by Morgenstein and Manace (1969) and suggested that it might result from an impaired blood flow in the cochlea due to sickled cells. Koide *et al.* (1964) postulated ischaemic changes in the cochlea: they demonstrated experimentally that cochlear venous blood had a low oxygen tension which made it conducive to sickling. It is now known that the cochlea, at the best of times, is poorly perfused and the hair cells highly susceptible to hypoxia. The blood supply is from end arteries with no collaterals hence ischaemic damage tends to be irreversible (Wright, 1987).

Odetoyinbo and Adekile (1987), in their study on patients aged six to 15 years, reported that 58.3 per cent of those who had SNHL, had their first vaso-occlusive episode occurring before the age of one year and more than 90 per cent before the age of five years, and therefore concluded that the cochlear microvasculature in young infants was more susceptible to occlusion during sickle cell crises.

Materials and methods

Fifty-two patients with homozygous HbSS attending the Sickle cell clinics at the St Bartholomew's and Whittington Hospitals in London were included in the study. The diagnosis of their homozygous state had already been made prior to our study. Their haemoglobin levels ranged from 6.5 to 9.8 gm per cent (mean 8.1 gm per cent). There were 28 male and 24 female patients whose ages ranged from eight to 57 years. The control group, matched for age and sex and whose haemoglobin genotype was AA, consisted of 36 patients who were attending the outpatients with non-otological problems.

A questionnaire was prepared to ensure uniformity of the information obtained from the patients. The salient points included a brief history of the presenting symptoms

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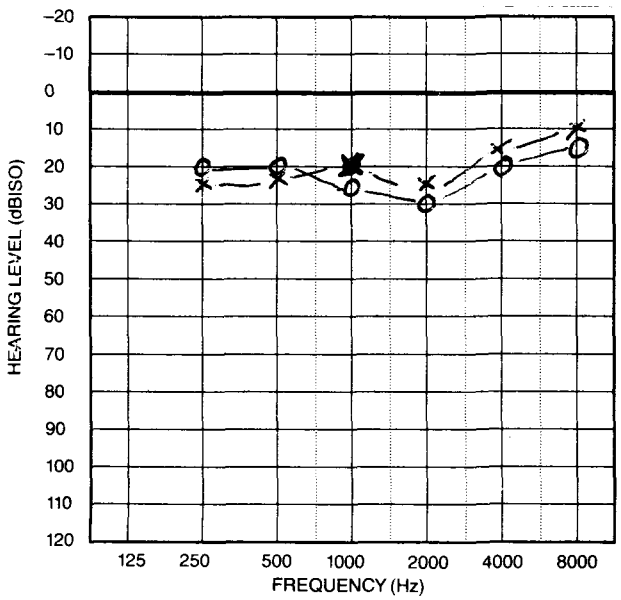
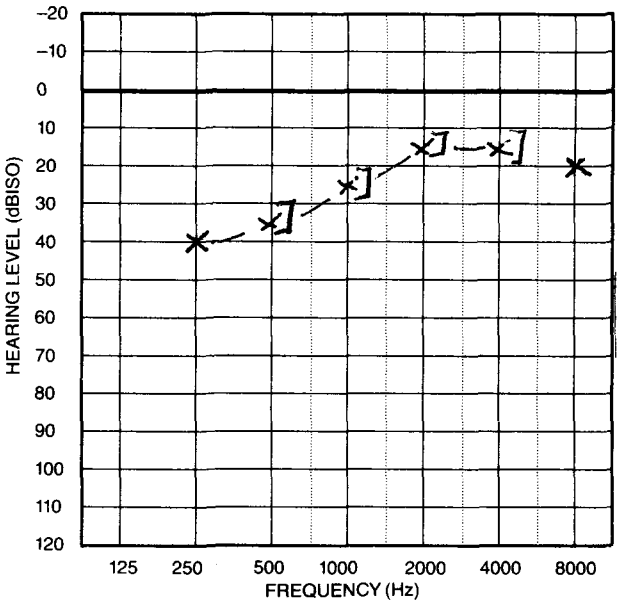
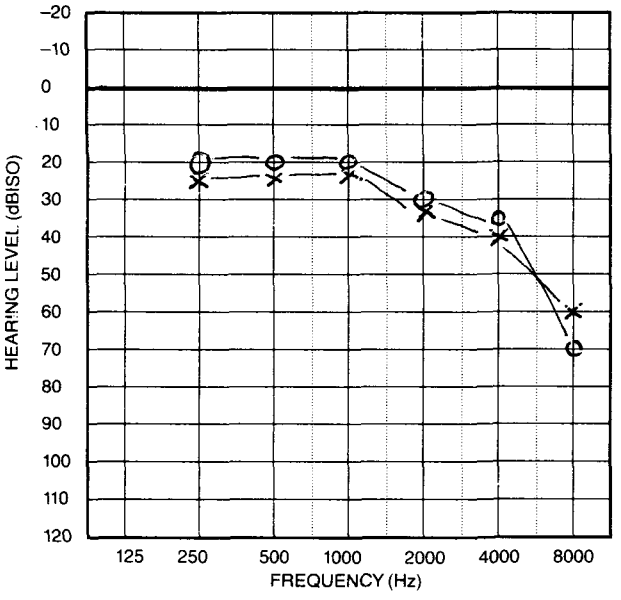


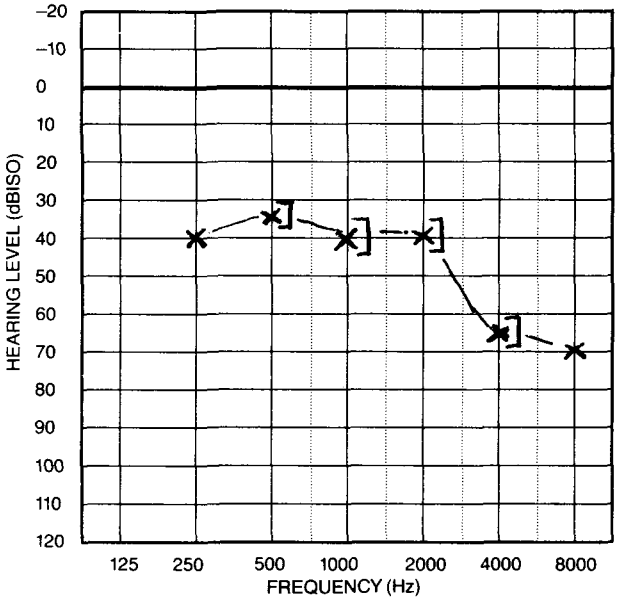
C.P. male 24 yrs.



M.S. female 19 yrs.



K.A. female 30 yrs.



J.M. male 17 yrs.

FIG. 1

and age at initial diagnosis, the number of vaso-occlusive crises, blood transfusions and also medications. Patients with any other known causes of deafness were excluded from the study. The patients in both the study and control groups were all interviewed and examined. Otological and audiological examinations were conducted on all the patients including the control group. The audiological assessment consisted of pure tone audiograms, tympanometry and acoustic reflexes. The audiometers were Kamplex AC4 and AC30 calibrated to British Standard 1988 while the tympanometer was a Grayson Stadler GSI 33 Middle-Ear Analyser. The test frequencies were from 250 to 8000 Hz. The criteria used to determine deafness were hearing loss greater than 20 dB at two or more frequencies in one or both ears. They were the same as those used by Todd *et al.* (1973), Odetoyinbo and Adekile (1987), Atsina and Ankra-Badu (1988) and Friedman *et al.* (1980) which are based on the standard set by the American Academy of Ophthalmology and Otolaryngology in 1959.

Results

Sensorineural hearing loss of more than 20 dB at two or more frequencies was recorded in seven of the 52 patients (13.5 per cent). It was unilateral in two and bilateral in five patients: 12 out of a total 104 ears (Figure 1). The two patients who had unilateral hearing loss were investigated to exclude any retrocochlear pathology. They had computerized tomography of the internal auditory canals and auditory brain stem responses. The results however were normal. There was no uniformity in the pattern of hearing

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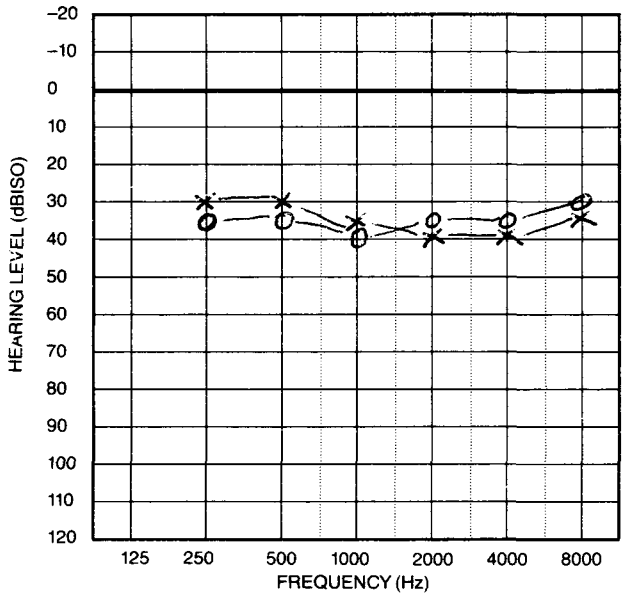
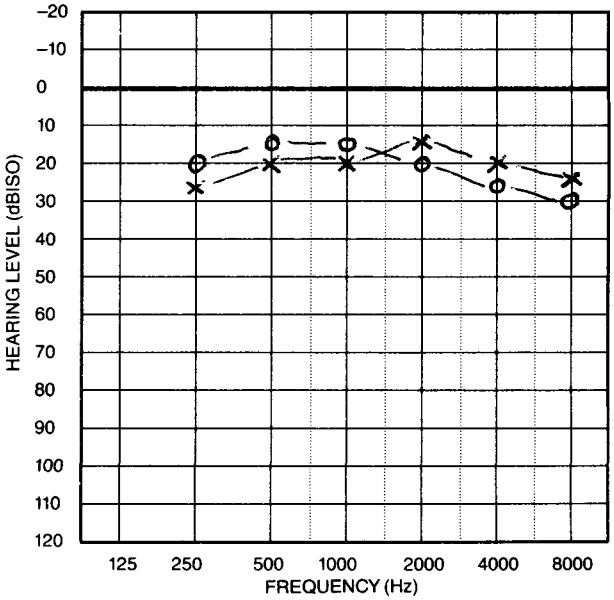
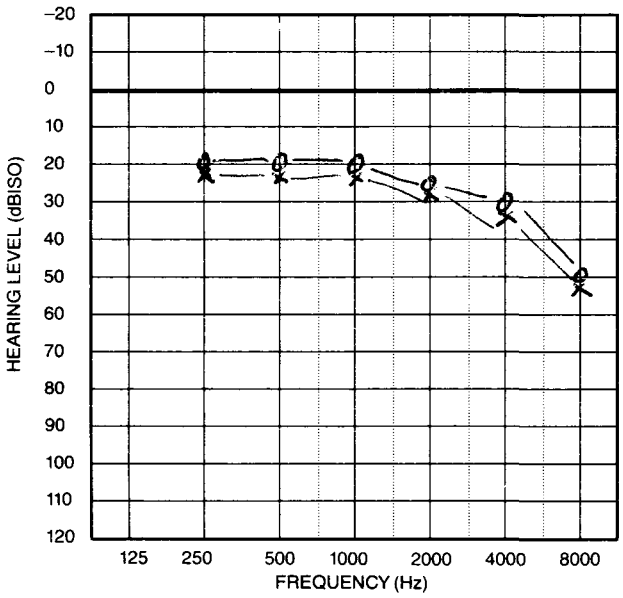


S.E. female 31 yrs



J.P. male 18 yrs



M.B. female 18 yrs

FIG. 1 (continued)
Pure tone audiograms showing different patterns of hearing loss.

loss; it affected different frequencies in the affected patients. While a 17-year-old male displayed a sloping high frequency loss, a 31-year-old female exhibited a symmetrical hearing loss ranging between 30 and 35 dB in all the tested frequencies (250 to 8000 Hz). Normal hearing levels were recorded in all the control group patients. Except for slight differences in the compliance, tympanometry was essentially normal in both the sickle cell and control group. Four out of the 12 ears with sensorineural hearing loss had either elevated or absent acoustic reflexes. One ear had some tympanosclerosis but did not register any demonstrable air–bone gap in the pure tone audiogram to suggest any middle ear pathology.

In the control group, none of the patients demonstrated any hearing loss. Using Fisher's Exact Probability test to compare hearing loss between the control and sickle cell groups, a significant result was achieved ($p<0.05$).

TABLE I

Age (yrs)	Number of patients	Number with hearing loss	Male/female ratio
0–10	1	–	1/0
11–20	11	4	7/4
21–30	26	2	12/14
31–40	12	1	6/6
41–60	2	none	2/0

Discussion

In our study, the audiograms of the 12 affected ears, showed no demonstrable involvement of the middle ears. The abnormal or absent reflexes, which often indicates a conductive hearing loss (Lutman, 1987), may in these cases indicate a slight middle ear involvement or damage to portions of the cochlea not apparent from the other measurements (Friedman *et al.*, 1980). As the manifestations of sickle cell disease are multisystemic (Serjeant,

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1985) and patients also suffer musculoskeletal growth retardation (Lowry *et al.*, 1978), the effect on stapedial function may not yet be fully understood.

Normal computerized tomography of the internal auditory canals and normal auditory brain stem responses in the two patients with unilateral hearing loss excluded any retrocochlear pathology. Elwamy and Kamel (1988) recorded abnormal ABR in sickle cell patients in crisis but concluded that it was most likely due to brain stem anoxia and was not related to the hearing loss. A cochlear origin is therefore more likely, a view which is supported by (Koide *et al.*, 1964; Serjeant *et al.*, 1975) who suggested vaso-occlusion of the cochlear blood vessels (a cochlear origin) as the cause of the hearing loss in sickle cell disease. Pollack and Lipscomb (1979) commented that the magnitude of hair cell damage which they found in the histopathology of human subjects was not often accurately represented in the pure tone audiograms.

Some authors (Orchik and Dunn, 1977; Friedman *et al.*, 1980; Odetoyinbo and Adekile, 1987) suggest additional neural involvement. There is now evidence that thrombosis and large-vessel intimal hyperplasia and occlusion also occur in sickle cell disease (Francis and Johnson, 1991). This may be the basis of the CNS infarction which is a well-known complication of the disorder (Hughes *et al.*, 1940). The consensus therefore is that sensorineural hearing loss in sickle cell anaemia is mainly cochlear in origin although a neural contribution cannot be excluded. The audiogram results (Figure 1) have no uniform pattern which suggests that different parts of the cochlea may be involved in different patients.

Our results (Table I), do not show any relationship between the incidence of hearing loss and age; a 57-year-old had normal hearing while a patient who was 17 years old had hearing loss. This is in agreement with Friedman *et al.* (1980), who did not find an increased incidence of hearing loss with increasing age, in contrast to Todd *et al.* (1973) who suggested in their study that the increased incidence of SNHL in the older age group might be because they may have suffered more vaso-occlusive episodes. This inference would be acceptable if these patients either had normal hearing before reaching the age groups concerned, or had evidence of progressive hearing loss over the years.

A relationship between sensorineural hearing loss and early occurrence of vaso-occlusive crises was suggested by Odetoyinbo and Adekile (1987) in their study of 56 children aged between six and 15 years. They found that 58.3 per cent of those who developed SNHL had their first vaso-occlusive crisis occurring before the age of one year and more than 90 per cent before the age of five years. Serjeant (1985) has also shown that about one third of children with sickle cell disease develop symptoms before their first birthday and over two-thirds before their second. Further studies on the younger age group is contemplated.

Early work by Kobak *et al.* (1941) reported a higher prevalence of complications of pregnancy in sickle cell anaemia. These include pre-eclamptic toxaemia, pneumonia, puerperal sepsis, impaired placental function by vaso-occlusion and severe anaemia. While haemoglobin levels fall in pregnancy, and reach the lowest levels between 32 and 34 weeks, this fall is more pronounced in sickle cell anaemia (Adams *et al.*, 1953) and levels of 13 per cent have been recorded. The resultant hypoxia, fever, dehydration and acidosis from these complications, would create a hostile environment for foetal development which in addition to the high foetal wastage, also cause low birth weight (Charache *et al.*, 1980), prematurity and intra-uterine infections (Freeman and Ruth, 1969). These factors, which are accepted as prenatal and perinatal causes of SNHL when they complicate pregnancies of foetuses with haemoglobin genotype AA, would have a more severe effect on the cochlea in sickle cell disease.

It is generally accepted that elevated levels of haemoglobin F (HbF) have a protective effect on the severity of the disease. While this may be true for organs such as the spleen, Ashoor and Al-Awamy (1985) have shown that it may not do the same for the cochlea. The rate of auditory complications of 23.8 per cent which they found, was similar to the figures of 21.7 per cent in earlier works by Todd *et al.* (1973) in Jamaica, 21.4 per cent in later works by Odetoyinbo and Adekile (1987) in Nigeria and 29 per cent by Atsina and Ankra-Badu (1988) in Ghana where the HbF levels are much lower.

The role of malaria in vaso-occlusive crises, in areas of the tropics where it is endemic, is important. Edington (1953) reported an increase in vaso-occlusive crises during periods of high malarial transmission and Konotey-Ahulu (1971a) reported that malaria accounted for 16 per cent of vaso-occlusive crises requiring hospital admission in Accra, Ghana. He also suggested that other infections may precede vaso-occlusive crises more frequently in the African environment than in the developed countries (1971b). The obvious reason is the lower standard of health care.

Our result of 13.5 per cent is similar to the 12 per cent reported by Friedman *et al.* (1980) in the USA, and much lower than in the developing countries who have the extra burden of malaria (21.4 per cent in Nigeria, 29 per cent in Ghana).

We suggest that further studies to identify, prevent or at least minimize the risks of developing sensorineural hearing loss in sickle cell anaemia should be directed to the foetus and the first few years of life.

Conclusion

Our study confirms that there is a higher incidence of sensorineural hearing loss mainly cochlear in origin in patients with sickle cell anaemia when compared to the population of the same age group and ethnicity in the UK which is in agreement with studies done in other countries. The hearing loss does not seem to increase in incidence or severity as age advances and there is no uniform pattern of hearing loss as shown in the audiogram results which suggests that different parts of the cochlea may be involved in different patients. The easier access to better health care may account for the lower incidence of sensorineural hearing loss in this study when compared with studies done in some developing countries where the disease is more common. We advocate that patients with sickle cell disease should be encouraged to have regular hearing assessment and this should be extended to all age groups.

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