

**MEDICAL MANAGEMENT OF INFANTS WITH SIGNIFICANT CONGENITAL
HEARING LOSS IDENTIFIED THROUGH THE NATIONAL NEWBORN
HEARING SCREENING PROGRAMME**
Best Practice Guidelines

Introduction:

This document was prepared in consultation with doctors involved with the 23 first phase sites for National Newborn Hearing Screening Programme (NHSP), in conjunction with the British Association of Audiological Physicians (BAAP) and British Association of the Community Doctors in Audiology (BACDA). It provides guidance for the doctors who are expected to undertake aetiological investigation of bilateral hearing loss of >40dBHL in infants identified through the NHSP programme. Unilateral hearing loss is outside the scope of this document.

These guidelines complement those issued by the professional bodies i.e. BAAP and BACDA⁷ and take into account the issues related to the diagnosis as early as a few weeks of age and the degree of hearing loss. It is expected that these guidelines will be incorporated into the recommended operational procedures for NHSP and will be reviewed and revised regularly as new evidence emerges.

General Guidance:

- Medical investigations including aetiology must be available to parents of infants with significant hearing loss, with full parental involvement

- Parents must be given comprehensive and unbiased information about the medical investigation which is carried out to identify the cause of hearing impairment and the diagnosis and treatment of any co-existing conditions, including both the benefits and the disadvantages, and be given every opportunity to further discuss their views and concerns with the doctor so that they can make an informed decision about whether they want their child to have these investigations and if so, the nature and timing.

- This information should be in an accessible form in a way that can be understood by parents

- There must be at least one doctor in each NHSP team. This doctor who should have achieved an appropriate level of competence²⁵ in explaining the investigations to parents and answering their queries, comprehensive and up to date knowledge of causes of hearing loss in children infants and neonates, investigating the aetiology of hearing loss in infants, interpretation of results and appropriate management of or referral route for any abnormalities found. The doctor should take the responsibility for further investigation and review of the aetiological diagnosis as and when required.

- The doctor could be an audiological physician, community doctor in audiology, paediatrician or an otolaryngologist with appropriate level of training²⁵ (see above – competency document) as defined by the professional bodies, and should be carrying out the process of aetiological investigation of deafness and examination of babies and children sufficiently often to be thoroughly familiar with the tasks.

- Parents must be kept informed at every stage of the investigations and should have reasonable access to the doctor for further information and explanation as required.

Benefits of aetiological investigations:

For parents, the child and professionals

- Provides an opportunity to explore the cause of the hearing loss
- Helps to get better advice from professionals with regard to possible progress and outcomes e.g. Connexin 26 deafness. If the diagnosis is known then the doctor can provide better advice to parents eg. progression of hearing loss with wide/dilated/enlarged vestibular aqueduct (EVA) and cytomegalovirus (CMV).
- May help to identify, monitor, treat or prevent complications in some patients e.g. neonatal infections such as CMV and cardiac conduction defects
- May help prevention or further deterioration of hearing loss e.g. CMV infection, wide vestibular aqueduct and A1555G mitochondrial mutation in susceptibility to aminoglycosides
- Facilitates better planning of future care for the child
- Enables more informed genetic counselling
- Enables better management of the child's hearing loss
- Allows improved information and advice for the child and family

The process of aetiological investigations:

- A systematic approach to aetiological investigations will maximise the opportunity to arrive at a diagnosis
- Aims and possible outcomes in relation to management should always be explained clearly and discussed with parents or carers.
- Choice lies with the parents but it is the responsibility of the doctor on the team to provide parents with information so that they can make an informed decision.
- Some parents may decide against investigations and their view should be fully respected.

Timing of investigations:

Investigations should be done as soon as possible, depending on parental readiness, and with regard for the health of the baby.

 **Some conditions associated with deafness, may take years to manifest e.g. retinitis pigmentosa in Usher's syndrome, goitre in Pendred's syndrome**

 **Aetiological diagnosis is an ongoing process. It must be reviewed and parents informed as new scientific and clinical information emerges.**

 **A positive investigation suggesting a cause may not necessarily mean that other causes are not implicated**

Reasons for carrying out aetiological investigations early:

See above

To Manage Progressive hearing loss

- CMV: to treat in an attempt to arrest progression of hearing loss
- EVA: to educate parents with a view to minimising fluctuations/progression of hearing loss.
- Familial: for advice on likely progression
- **To Treat some conditions**
- CMV
- Long QT: to minimise risk of cardiac complications
- Meningitis: to fast track for Cochlear implant if necessary

To enable prompt management

- Early genetic opinion on recurrence risks and syndromal diagnosis
- Some investigations could be carried out under natural sleep
- Better planning and management of hearing loss

 **The yield from and the usefulness of certain investigations can be age dependent**

 **When Investigations are not carried out the reason should be clearly stated in the notes**

Levels of Investigations:

Core: Should definitely be offered in all cases of hearing loss greater than 70dB and may be considered in other cases²⁸.

Additional: These investigations should be considered if there is a specific clinical indication

Core Investigations

a) History

General history

Record detailed history of the pregnancy and maternal health in the pre-natal period, details of peri and postnatal period, developmental milestones including motor milestones, history of ototoxic medication, head injuries, ear disease, meningitis or viral illness and immunisation status.

Family History (FH)

Chart Family History of hearing loss or risk factors associated with hearing loss in at least 3 generations to include siblings, parents and grand parents.

Examination of maternity and perinatal notes may also provide useful information

b) Examination

Perform physical examination including inspection and measurement of the cranio-facial region, eyes and ears. W index should be calculated where indicated. Examine the neck, skin and nails, limbs, chest and abdomen. Perform or arrange full developmental assessment

c) Family audiograms

Obtain hearing assessment of first-degree relatives. Previously unsuspected audiometric abnormalities may be present. In families where there is established deafness, the degree of hearing loss may vary within the same condition (eg. Waardenburg Syndrome)

d) Specific Investigations (see General Guidance page 1)

1. Imaging:

Includes imaging the ear and its anatomical connections as well as imaging other parts of the body that may be affected.

i) Radiology of the head and neck (Core)^{3,4,5,26}

- Computerised Tomography (CT) of petrous temporal bones
CT scan involves radiation. It will show the bony structures including middle ear ossicles
- Magnetic Resonance Imaging (MRI) of inner ears and the internal auditory meati (IAMs)
MRI will show soft tissues (e.g. brain, VIIth and VIIIth nerves and membranous labyrinth, including endolymphatic sac.

It is important to give a clinical summary and a list of suspected abnormalities so that the radiologists can select the optimal scan protocol.

Which patients should be offered imaging?

- All cases with severe to profound bilateral hearing loss
- Children with mild to moderate bilateral hearing loss may be referred for imaging at a later stage
- In all cases this should follow full discussion with parents.

When should imaging be considered early?

- Post meningitis / recurrent meningitis
- Cochlear Implant (CI) assessment (CI centre)
- Progression or fluctuation of HL
- Where there are structural renal abnormalities
- If recurrence risk and genetic diagnosis is important to parents and physicians

Timing

CT and MRI can be carried out from birth and the timing depends on when the parents are ready and what action is planned.

Infants and children over 3 months of age will normally need sedation for radiological investigations and in children above the age of 2 years this may be in the form of heavy sedation or a general anaesthetic (GA). This depends on local protocols.

ii) Renal ultrasound (Additional)

Indicated if branchio-oto-renal syndrome is suspected (i.e. pre-auricular pits, branchial sinuses) or if there are multiple (or multi-system) abnormalities or FH of renal problems.

Examination of hospital notes may be helpful, as this may have been done already
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2. Electrocardiography (ECG) (core) ^{8, 11, 16, 20, 22, 23}

The only known association between ECG abnormalities and hearing loss is in Jervell Lange-Nielsen syndrome (JLNS) which is a rare autosomal recessive conditions with long QT interval and sensorineural; hearing loss. This is due to the homozygosity for mutation in the KVLQT1 gene.

Long QT syndrome is characterised by syncope and sudden death. JLNS accounts for <1% of long QT syndrome (Zareba) and the population prevalence is estimated to be somewhere between 1:160,000 to 1:600,000 (Bitner). There is high incidence of consanguinity in the parents of affected children (Bitner). This means that the prevalence of JLNS when the parents are unrelated is extremely low.

Currently it is recommended that only the babies with severe to profound hearing loss especially when there are vestibular abnormalities should have this investigation.

Those babies with a **corrected** QT interval greater than that expected for their age need to be reviewed by a paediatric cardiologist.

3. Genetics (Core) ^{10, 12}

All genetic tests, their purpose, process and possible outcomes, and advantages and disadvantages of each test must be discussed clearly and in detail with the family. Every opportunity should be given for the family to understand the tests and take an informed decision as to whether they would prefer for their child to be investigated or not. The possibility that blood samples may be stored for future investigation needs to be discussed with parents.

 written consent should be obtained if blood samples are stored and used with a view to carrying out investigations in the future.

The following tests are recommended:

i) where there is bilateral severe or profound hearing loss, test for **Connexin 26 and 30** mutations

Note:

- *Pickup rate of Connexin 26 and 30 mutations is much lower in cases of mild to moderate bilateral SNHL*
- *A negative result does not exclude autosomal recessive hearing loss or other types of genetic HL*
- *Referral to a clinical geneticist should be discussed with the family*
 - *If the result of the test is not clear cut*
 - *if there is only one mutation found*
 - *if sequence variants are of unknown pathogenicity*
 - *If there are two different mutations in the Cx 26 gene.*

ii) Where there is a maternal family history of hearing loss or hearing loss following exposure to aminoglycosides – **test for A1555G** mitochondrial mutation. Consider other mitochondrial mutations depending on the family history

iii) Where there is developmental delay or dysmorphic features – test for **chromosomal abnormalities** (Additional – see section 6)

The above should be offered soon after the hearing loss is diagnosed.

Referral for genetic counselling should be dependant on local protocols which should be developed with the geneticists i.e. some geneticists may prefer to request molecular tests once they have seen the family.

In the case of a positive diagnosis, parents should be presented with written information on the implications for their child and any future children

4. Infection screen (core) ^{1, 6, 13, 15, 17, 18, 19, 21}

i). **CMV** – Commonest intrauterine infection causing hearing loss in the UK.

Congenital CMV is found in up to 0.5% of all births in the UK and about 4% of these will be deaf at birth. This will rise to about 8% by the age of 5 years (i.e. can cause progressive hearing loss)

- <3 weeks of age the virus cultured from blood, urine or throat swab indicates congenital infection. After 3 weeks virus isolation could be due to acquired infection, which is not normally associated with adverse outcome.
- >6 months of age – absence of IgM and IgG excludes CMV infection
- Using samples taken at the Neonatal Biochemical screen (heel prick) for diagnosis of CMV

ii). **Rubella**

- Birth – 3 months – IgM +ve (clotted blood) 100% of cases
- 3-6 months – IgM +ve in 90% of cases
- Absence of IgG after 1 year excludes congenital infection
- 6 months to 3 years absence of Rubella specific T cell response (heparinised blood) excludes Rubella

iii). **Toxoplasma** (additional)

i. Up to 6 months IgM +ve

ii. Presence of IgM in maternal blood and IgG in baby's blood beyond 10 months of age is diagnostic

iv). **Syphilis** (additional)

i. Maternal screening no longer universally carried out. Serology can be carried out any time up to teenage years

 maternal immunisation status may not be significant

 consider local population variations

5. Ophthalmology (core) ^{2,9,14, 24}

40% of children with sensorineural hearing loss have additional needs and/or ophthalmic conditions. Eye problems may include non-specific problems of squint and refractive errors. In some children the eye examination may help to make or clarify an aetiological diagnosis such as CHARGE, Usher Syndrome congenital CMV or Rubella

- All children should be referred for full ophthalmic assessment at the time of diagnosis.
- The timing of further assessments is detailed in the NDCS/Sense Quality Standards 2004²⁴.
- Ask about visual problems at follow-up visits.

Specific Investigations (Additional)

6. Blood tests

It may not be desirable to obtain large amounts of blood from a small baby and it must be remembered that some of these tests may have been carried out as part of general paediatric management

Haematology

- Full blood count, haemoglobinopathy screening and ESR have a very low yield. Further, it may be difficult in the neonate to obtain sufficient amount of blood for all the investigations and therefore the above should carry a low priority over the other investigations.

Biochemistry

- Urea and electrolytes and serum creatinine are useful in excluding renal function abnormalities and may be used if conditions such as Alport or Alstrom's syndromes are suspected.
- Thyroid function – by 6 weeks most babies should have had a TSH screen together with the Neonatal Biochemical screen and therefore hypothyroidism should have been excluded.

Genetics and Chromosomes

- See section 3

Infection Screen

- See section 4

 Ensure appropriate sample bottles are used

7. Urine examination

Check the notes as these investigations may have already been done
i). Metabolic screen when a metabolic problem is suspected (e.g. failure to thrive, developmental delay)

ii). Urine microscopy – may not be positive during the first few years of life in Alport syndrome especially if only one sample is tested²⁷, but this will be important if there is a family history of haematuria

Explaining the results of the investigations, the interpretation and making an aetiological diagnosis, and review of such diagnosis at the appropriate time is the responsibility of the doctor. Parents must be given adequate information in oral and written format so that they can understand the reasons for carrying out aetiological investigations, advantages and disadvantages and the possible outcomes at every possible occasion. These guidelines must be reviewed regularly, as new evidence may emerge that may lead to a change in practice.

References:

1. Ahlfors K, Ivarsson S-A, Harris S. Report on a long-term study of maternal and congenital cytomegalovirus infection in Sweden. Review of prospective studies available in the literature. *Scand J Infect Dis* 1999; 31:443-457
2. Armitage AK et al, Visual impairment in severe and profound sensorineural deafness. *Arch Dis Child* 1995 ; 73 :53-56
3. Bamiou DE, MacArdle B, Bitner-Glinzicz M, Sirimanna T. Aetiological investigation of hearing loss in childhood: A review (98 references) *Clinical Otolaryngology & Allied Sciences*. 25(2):98-106; 2000 Apr.
4. Bamiou DE., Phelps P., Sirimanna T. Temporal bone computed tomography findings in bilateral sensorineural hearing loss. *Arch. Dis in Childhood*. 82(3):257-60, 2000 Mar.
5. Bamiou DE., Savey L., O'Mahoney C., Phelps D., Sirimanna T. Unilateral sensorineural hearing loss and its aetiology in childhood: the contribution of computerised tomography in aetiological diagnosis and management. *International J of Paed. Otorhinolaryngology*. 51(2):91-9, 1999 Dec.
6. Barbi M, Binda S, Caroppo S et al. A wider role for congenital cytomegalovirus infection in sensorineural hearing loss. *Pediatr Infect Dis J* 2003; 22:39-42
7. Best practice guidelines for aetiological investigation of hearing loss, British Association of Audiological Physicians, 2002 (www.baap.org.uk)
8. Bitner-Glinzicz M, Tranengoerg L. The Jervell Lange-Nielsen Syndrome. *Adv. Otolaryngol*. 2000:56:45-52
9. Brinks MV et al. Ophthalmological screening of deaf students in Oregon. *J Paediatr Ophthalmol.& Strabism*. 2001; 38(1):11-15
10. Denoyelle F et al. Clinical features of the prevalent form of childhood deafness, DFNB1, due to a connexin-26 gene defect: implications for genetic counselling. *The Lancet*,1999; 353: 1298-1301.
11. El-Habbel MH, Mahoney CO. QT interval in children with sensorineural hearing loss. *PACE* 2002;25:435-9
12. Estivill X et al. Connexin 26 mutations in sporadic and inherited sensorineural deafness.*The Lancet*, 1998; 351 394-398.
13. International Herpes Management Forum. Herpesvirus infections in pregnancy. Recommendations from the IHMF Management Strategies Workshop and 7th Annual Meeting 1999. Eds Pass R, Weber T, Whitley R.J. Available from <http://www.ihmf.org>
14. Mets MB et al. Early diagnosis of Usher's syndrome in children. *Tr Am Ophth Soc*. 2000 ;98 :237-245
15. Miller E, Craddock-Watson JE, Pollock TM. Consequences of confirmed maternal rubella at successive stages of pregnancy. *Lancet* 1982; Oct 9;2(8302):781-4.
16. Ocal B, Imamoglu S, Atalay S, Ercan Tutar H. Prevalence of Idiopathic Long QT syndrome in children with congenital deafness. *Paed Cardiol* 1997; 18:401-5
17. Peckham CS, Stark O, Dudgeon JA, Martin JAM, Hawkins G. Congenital CMV infection: a cause of sensorineural hearing loss. *Arch Dis Child* 1987; 62:1233-1237
18. Peckham C, Tookey P, Logan S, Giaquinto C. Screening options for prevention of congenital cytomegalovirus infection. *J Med Screen* 2001 8: 119-124
19. Rivera LB, Boppana SB., Fowler KB et. al. Predictors of hearing loss in children with symptomatic congenital cytomegalovirus infection. *Paediatrics*. 110(4):762-7, 2002 Oct.
20. Schwartz PJ, Moss AJ, Vincent GM et al. Diagnostic criteria for long QT syndrome: an update. *Circulation* 1993;88:782-4
21. Tookey PA, Peckham CS. Surveillance of congenital rubella in Great Britain, 1971-96. *BMJ* 1999; 318:769-70
22. Tuncer C, Cokkeser Y, Comsuoglu B et al. Assessment of ventricular depolarisation in deaf-mute children. *Paediatr Cardiol*. 2000:21:135-40
23. Zareba W, Moss AJ. Long QT syndrome in children. *J Electrocardiol*. 2001:34:167-71
24. NDCS/Sense. Vision care for deaf children and young people, 2004.
25. BACDA Competencies for investigating the cause of hearing impairment in babies identified through the newborn hearing screening programme, 2004, Unpublished.
26. Ionising Radiation (Medical Exposure) Regulations 2000. (IR(ME)R)
27. Sirimanna T, Stephens D, Hearing Loss in Alport syndrome. *Journal of Audiological Medicine*, 1997; 6 (2), 71-8.
28. Watkin PM, Baldwin M. Confirmation of Deafness in Infancy. *Arch Dis Child* 1999; 81:380-389

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