CONDUCTIVE DEAFNESS FOLLOWING HEAD INJURY: REPAIR OF A DISLOCATED INCUDOSTAPEDIAL JOINT BY WIRING*

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The mechanism and nature of injury to the ossicular chain have been studied and understood only comparatively recently. With the operating microscope it has become possible to verify a diagnosis of disruption of the ossicular chain and to treat the condition. The diagnosis is more frequently made because of (*a*) increased awareness of the entity by otologists and neurosurgeons, and (*b*) the increase in traffic accidents.

It is of obvious medico-legal importance.

ANATOMY AND MECHANISM

Congenital interruption of the chain occurs, but is rare. This is rather surprising when one considers that the malleus and incus develop from the first visceral arch and the stapes and stapedius muscle from the second arch.

Inflammatory causes for incudostapedial separation are common.

Accidental interruption of the ossicular chain during surgical procedures, e.g. stapes mobilization or cortical mastoidectomy, is well known. This paper is concerned with the interruption of the chain due to head injuries.

Considering the anatomy of the ossicular chain, it is easy to see where the *locus minoris resistentia* is located. The malleus is firmly attached to the anterior and posterior malleolar ligaments and to the eardrum. The footplate of the stapes is enclosed by the annular ligament, but the incus, apart from a few strands of connective tissue in the fossa incudis, lacks anchorage by firm ligaments. Its loose suspension predisposes to dislocation. Out of 13 cases subjected to operation by Does and Bottema,[1] 9 involved various degrees of incudal displacement and the other 4 had fractures of the stapes crura.

Ballantyne[2] considered traumatic disruption an event worth reporting and presented a case of incudostapedial separation treated by him. Gisselsson[3] reported a case of bilateral incudostapedial separation.

The malleus, though not immune to injury, is rarely displaced, and Hammond[4] reported a case following head injury, in which the malleus was found lying on the promontory embedded in a few strands of fibrous tissue. Sade[5] reported a case in which the footplate of the stapes was shattered.

Most of these traumatic lesions follow severe head injuries.

Hough[6] proposed three possible mechanisms for the production of incudostapedial disruption:

(*a*) Due to a severe impact a vibratory reaction is set up, causing momentary weakening and separation of tissues. This sounds very nebulous. He also refers to an 'explosion' among the cells.

(*b*) Newton's law of motion related to inertia.

(*c*) Sudden tetanic contraction of the intratympanic muscles. The stapedius muscle of the cat exerted a pressure of 1 G under experimental conditions. Transposed to man, this would represent a substantial force and would be directed against the smallest, the finest and most delicate joint of the human body.

Does and Bottema[1] state that during the trauma the skull, including the middle ear, is most likely distorted in such a way as to displace the incus.

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DIAGNOSIS

History

Severe cranial trauma, often with bleeding from the ear, is followed by persistent conductive deafness. Conductive deafness due to haemotympanum or a tear of the tympanic membrane is temporary, unless infection supervenes. The trauma may have occurred very long ago and may be almost forgotten. Thorburn[7] successfully operated on a patient who had had a head injury 15 years previously, and Freeman[8] successfully repositioned an incus dislocated 16 years earlier at cortical mastoidectomy when the patient had been 5 months old. There was an immediate gain in air-conduction hearing of 60 db.

Otoscopy may show the tympanic membrane to be intact but may show cicatrization of the posterior superior quadrant.

Audiometry

There is a severe conductive hearing loss with a Rinne-negative response, and the Weber sign lateralizes to the affected ear. The air-conduction and bone-conduction curves are parallel, and Carharts notch is absent.[9] Interruption of the ossicular chain causes a near-60 db. conductive hearing loss. This extensive loss can be explained as follows:

(*a*) The middle-ear transformer mechanism is lost, which otherwise overcomes the loss incurred when airborne sound energy is transferred to the denser medium of fluid (Fig. 1).

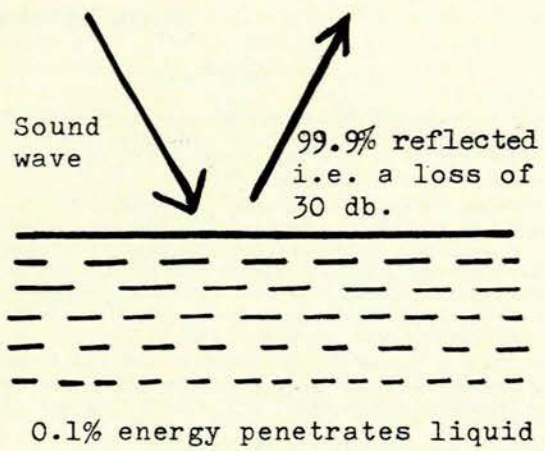

Fig. 1. Loss of 30 db. in transfer of sound energy from air to liquid medium.

The transformer action is made up of: (*i*) the large surface area of the tympanic membrane which collects vibratory energy, which is concentrated on the small area of the stapedial footplate—this represents a gain of a ratio of 28:1; and (*ii*) the mechanical-lever advantage of the ossicles which adds another 2 db.

(*b*) Not only is the transforming action of 30 db. lost in the event of incudostapedial separation, but the intact tympanic membrane shields the oval and round windows. The very much reduced sound energy reaches the windows in nearly equal force and phase.

Impedance Studies

The stapedius reflex is usually elicited by a sound stimulus of 70 - 90 db. The resulting increased impedance can be measured by the electro-acoustic impedance meter. Inconstant results were obtained by Does and Bottema.[1]

Tomography

Gross ossicular displacement may be shown by tomography.[10]

Usually the diagnosis cannot be made with certainty, but it is confirmed by exploratory tympanotomy.

TREATMENT

Treatment is always operative. The exact method will depend upon the findings at operation. Different authors have used the following methods:

Ballantyne,[2] in his case of incudostapedial separation, interposed a polythene tube between the lenticular process of the incus and the head of the stapes. This was initially successful, and then deteriorated. At re-tympanotomy he found that the polythene tube had moved off the stapes. He then proceeded with a stapedectomy and inserted a Schuknecht fat-wire prosthesis.

Hough[6] uses myringostapediopexy or repositioning of the lenticular process of the incus on the head of the stapes or an autogenous bone graft for the repair of the incudostapedial separation.

Does and Bottema[1] prefer incus repositioning or amputation of the malleolar head and myringo-incudopexy or removal of the incus and infraction of the malleus head, interposing it between the head of the stapes and the tympanic membrane, or interposition of a polythene strut between the malleolar neck and the stapes head. For fractured stapes crura they advocate interpositioning of a pellet of connective tissue or a teflon prosthesis interposed between the malleolar neck and the stapes footplate.

Ankleseria[11] performs the ossiculoplasty of Hall and Rytzner.[12,13] He extracts the incus, trims the long process and replaces it so that the short process abuts against the stapedial head, and the body supports the tympanic membrane.

A CASE REPORT AND METHOD OF REPAIR

Three months before being seen, a 7-year-old boy sustained head injuries and a right haemotympanum after falling from a bus. He presented with a normal, intact, mobile tympanic membrane but a severe conductive deafness, the hearing loss averaging 60 db. (Fig. 2).

Exploration was undertaken via a postaural approach. The incudostapedial joint was widely separated. Repositioning resulted in prompt redisplacement of the lenticular process. A length of Schuknecht silver wire was fashioned as a double hook, and was hooked between the crura of the stapes and around the long process of the incus, thus re-establishing continuity of the chain (Fig. 3). A round-window reflex was obtained by tapping the incus.

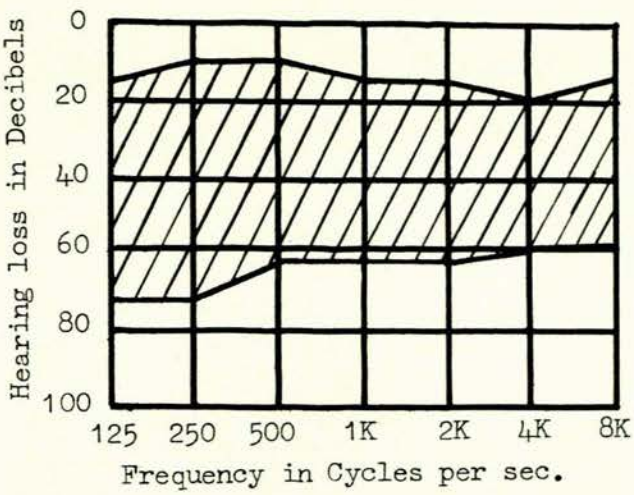

Fig. 2. Audiogram showing the pre- and postoperative hearing levels and the gain in air-conduction hearing.

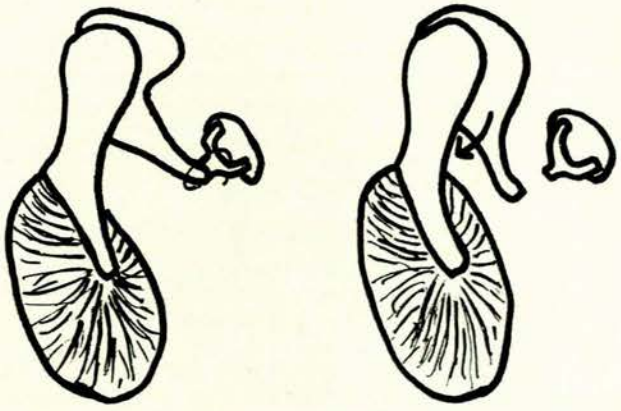

Fig. 3. The dislocated incudostapedial joint repaired by wiring.

A postoperative audiogram showed almost complete closure of the air-bone gap (Fig. 2). This has been maintained up to the time of writing, 10 months later.

SUMMARY

Conductive deafness after head injury is mostly due to haemotympanum or traumatic perforation, and usually recovers completely. Disruption of the ossicular chain should be suspected if hearing does not recover after healing of the drumhead. The hearing loss is commonly severe and in the order of 60 db. Air conduction parallels bone conduction, and Carharts notch is absent. Tympanotomy is imperative under these circumstances. Dislocation of the incudostapedial joint is by far the most common lesion. Incus repositioning is the preferred method of repair. A case is reported where successful repair was effected by wiring with silver wire.

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ADDENDUM

An adult male was referred from the neurosurgical department with facial paralysis following a head injury. He was found, in addition, to have a profound conductive deafness. At tympanotomy the incudostapedial joint was found to be widely disrupted. Wiring, as described above, resulted in a similar dramatic hearing improvement when tested audiometrically 1 week postoperatively.

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