Persistent Dizziness Following Head Trauma and Perilymphatic Fistula

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A growing body of evidence supports the idea that dizziness that persists for months and even years can be caused by an unsuspected perilymphatic fistula. Perilymphatic fistulas are abnormal ruptures that allow perilymph to leak out of the inner ear into the middle ear space. Most commonly, these ruptures occur secondary to a traumatic event. The term postconcussive syndrome has been used to describe a myriad of symptoms following head trauma. Some of these symptoms, such as cognitive changes, tinnitus, neck stiffness, and dizziness, are also commonly caused by active perilymphatic fistulas. This article discusses the typical history and diagnostic tests for patients with perilymphatic fistula. Common diagnostic tests include audiograms, electronystagmograms, electrocochleograms, and subjective and platform fistula tests. Also, the surgical treatment for the perilymphatic fistula (ie, repair of the oval and round windows) is reviewed, along with the results produced by this relatively minor ear operation. Suggestions are made to help the medical professionals involved in rehabilitative care to be aware of perilymphatic fistulas and seek proper consultations from inner ear specialists if they suspect the existence of this easily cured disorder.

INTEREST IN vestibular rehabilitation is increasing in the fields of physical medicine and rehabilitation (PMR) and in physical therapy (PT). Many advances have occurred in designing both exercise approaches and rehabilitative strategies to maximize recovery and increase productivity of individuals with disorders of the vestibular system.[1-5] Specific therapies have been developed for a discrete peripheral vestibular disorder called benign paroxysmal positional vertigo (BPPV).[6-8] Many patients with head trauma are admitted to rehabilitative centers without having been seen by specialists in peripheral vestibular disorders, eg, neurotologists and otoneurologists. The patients are assumed to have fixed concussive injuries to either the central nervous system or the inner ear or both. Such injuries might resolve with time and therapy but can also cause long-term disabling vestibular symptoms.[9] Undetected among patients with such concussive injuries are many with perilymphatic fistula (PLF), a discrete, treatable inner ear disorder. The surgical repair of these inner ear fluid leaks has uniformly resulted in prompt and sometimes dramatic improvement in the patients' vestibular function. Other symptoms often incorrectly attributed to a post-concussive syndrome will likewise resolve after surgery.

PERILYMPHATIC FISTULA

A PLF is an abnormal connection between the perilymphatic fluid compartment (one of the two inner ear fluids) and another space, usually the middle ear. This connection is a rupture of either the ligamentous attachment of the stapedial footplate to the bone of the oval window or the round window membrane. This rupture allows perilymph to leak out of the inner ear, producing a vestibular disturbance and/or hearing loss. Vestibular disturbances are more frequent than a hearing loss from the PLF. The entire human inner ear contains only 0.032mL of perilymph. The exact pathophysiology of the vestibular disorder and hearing loss is not known but is commonly believed to be caused by an endolymphatic hydrops that occurs secondary to the loss of perilymph. Endolymphatic hydrops is the known pathological substrate of Meniere disease, an idiopathic disorder of the inner ear.

The incidence of a PLF following head trauma is unknown but the cause of PLFs in most large series is trauma in 30% to 60% of the cases.[10-12] In our series of 200 cases of PLF the cause was head/ear trauma in 38% (unpublished data, 1994). It cannot be determined how many cases go undiagnosed. Alerting physicians to the existence of this disorder, however, will help reduce the number of undiagnosed cases.

The first report of a traumatic PLF was by Fee[13] in 1968. He reported three cases of traumatically induced PLF diagnosed at the time of middle ear surgery. The first case was diagnosed and followed-up for 7 months as a traumatic Meniere syndrome before the correct diagnosis was made. Three years later Goodhill[14] coined the terms "explosive" and "implosive" routes of pressure transfer to the perilymph system. An explosive PLF occurs when there is a sudden increase in the intracranial cerebrospinal fluid (CSF) pressure. CSF and perilymph are directly continuous and this pressure wave is transmitted immediately from the CSF to the perilymph fluid in trauma such as a head blow. This can result in a blow out of the round window membrane or the oval window membrane, or both. A pathway is then created for the perilymph to escape into the middle ear. An implosive PLF occurs when a pressure force is applied to the tympanic membrane driving the stapes into the inner ear, causing a tear in its attachments to the oval window, eg, a hand slap to the ear.

Since 1968, more than 150 articles have chronicled the development of our understanding of the PLF. Two landmark articles deserve special attention. Grimm et al[15] illustrated the broad array of symptoms caused by a traumatic PLF and raised our awareness that many of the components of a typical postconcussive syndrome in actuality often are caused by a PLF. Furthermore, closure of the PLF brings prompt and often complete reversal of not only vestibular problems but also stiff neck, perceptual and cognitive difficulties, and a general reduced ability to function. In Grimm's series of 102 patients with mild head trauma, fewer than half had no loss of consciousness and

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one-third had a whiplash injury only. The second article is an exhaustive review of the PLF literature by Strohm.[16]

DIAGNOSTIC CRITERIA

Criteria for the diagnosis of a PLF are not universally established. Almost every writer stresses a combination of historical data, typical symptoms, and diagnostic tests. Even then, the diagnosis can be unsettling for clinicians who are inexperienced in treating these patients.

The historical data of interest: (1) onset of symptoms following trauma (direct head/ear, whiplash, barotrauma, acoustic trauma); (2) exacerbation or recurrence of symptoms following trauma; (3) symptoms (constant or intermittent): disequilibrium, ataxia, vertigo, dizziness, hearing loss, cognitive and visual perception difficulties.

Physical examination (first visit): (1) otologic and cranial nerve exam; (2) cerebellar tests; (3) sharpened (tandem) or regular Romberg Test; (4) Fukuda stepping test; (5) Singleton eyes-closed turning test; (6) subjective fistula test.

The otologic and cranial nerve exam and the cerebellar tests are usually of little help in diagnosing PLF. The Romberg, Fukuda, and Singleton tests are often positive in patients with PLFs but are not specific for the disorder. If the subjective fistula test is positive, the likelihood that the patient has a PLF is 85% to 90% (unpublished data, 1994). This test greatly simplifies the task of making the diagnosis. The patient is seated or lying and is asked to fix his vision on an object across the room. A pneumatic otoscope is perfectly sealed in the external ear canal and erratic pulses of air pressure are applied 8 to 10 times in each ear. The patient is asked the specific question "Does that bother you?" It is a negative response if the patient replies that there was pain or pressure. If, however, the patient says that the object he was watching moved, or he felt a sense of self-motion or nausea, this is a positive response that strongly suggests an active PLF. This test is only 50% sensitive, however; this may be caused by the intermittent nature of some PLFs, as they frequently heal and reopen.

DIAGNOSTIC TESTS

Imaging

Most patients admitted to a rehabilitative center after head trauma have already had numerous imaging studies. Most of these studies, ie, computed tomography (CT) scan or magnetic resonance imaging (MRI) scans, are not performed in a way to detect the subtle changes in the inner ear that help diagnose a PLF.

Mark and Fitzgerald[17] published a report on high resolution MRI of the temporal bone with gadolinium enhancement that revealed inflammatory changes in the inner ear. Some of these cases were secondary to inflammation produced by a PLF.

High resolution CT scans of the temporal bone are also necessary to rule out the temporal bone fractures known to cause PLFs. This type of CT scan is usually not performed in a head trauma patient because the trauma team is mostly concerned about intracranial hemorrhage or brain damage that can be detected on a quick noncontrast CT scan.

Auditory Tests

Standard air/bone and speech tests may show a unilateral hearing loss, which is usually a strong clue as to which ear may have a PLF. PLFs usually do not cause a hearing loss but if one has occurred, it most often is a sensorineural hearing loss. Infrequently, there will be a mixed conductive and sensorineural pattern caused by a PLF. A tympanogram might show old blood or CSF in the middle ear space, which also a clue to a temporal bone fracture. Acoustic reflex testing and auditory brain stem evoked response (ABR) testing can detect brain stem and midbrain lesions causing a central vestibular disorder.[18] Electrocochleography (ECOG), an objective noninvasive measuring tool for the volume of endolymph in the inner ear, is often mildly elevated in PLFs and when moderately/markedly elevated indicates traumatic Meniere syndrome.[19,20] A newer diagnostic tool, evoked otoacoustic emissions, offers the possibility of objectively testing the integrity of the inner ear's hair cells for improved site of lesion auditory testing.[21] This test should be abnormal in hearing losses caused by PLFs, but it would also be abnormal in cochlear concussion and traumatic Meniere syndrome.[22]

Vestibular Testing

The electronystagmography (ENG) test, actually a battery of tests, is the most widely used tool to evaluate the central and peripheral vestibular system.[23] The most consistent finding in PLFs is abnormal positional tests (positional nystagmus) and, less commonly, a reduced vestibular response on caloric testing.[24] Sinusoidal harmonic acceleration testing has been used infrequently in diagnosing a PLF.[25] Platform posturography has not been helpful in PLF diagnosis. An application of the platform test, the platform pressure test or platform fistula test, has been the best diagnostic test found yet for a PLF.[26] Our experience with this test has shown a 50% sensitivity, 63% specificity, and a positive predictor of abnormal of 93% (unpublished data; 1994).

The platform pressure test uses the vestibulospinal reflex as an indicator of a patent perilymphatic fistula. The subject stands, eyes closed, on a platform capable of measuring anterior-posterior and lateral sway movements. Measurements are recorded for 10 seconds with the platform earth fixed, then sway is referenced to hip movements for baseline data. Because eyes are closed and because the sway-referenced platform movement removes accurate ankle joint and foot support body-sway angle information, the patient is left with only vestibular input for sensory control of postural sway. Air pressure is introduced into the ear canals one at a time, by means of standard tympanometric equipment. The pressure is sinusoidally modulated between +400mm and −400mm H_2O. If the postural sway has a peak amplitude in the A-P or lateral direction greater than two standard deviations from a normal base, the test is scored as positive.

OPERATIVE PROCEDURE

The surgery to repair a PLF requires about 1 hour and is usually performed while the patient is under general anesthesia. The approach to the middle ear is through the ear canal, using an operative microscope. Once the eardrum is reflected out of the way, the oval and round windows can be observed. Actual fluid leaks are observed only 25% to 30% of the time. Both windows are packed with a small soft tissue graft. The patient is hospitalized overnight, then discharged to rest at home for the next 3 days. The risks of the operation are minimal.

RESULTS OF SURGERY

Surgical outcome is reported here for the vestibular symptoms only. Most investigators report a success as complete or near-complete cessation of vestibular symptoms. These results are also pooled from all etiologies because no large series have been reported on traumatic PLFs only. Relief of vestibular symptoms was reported by Shelton and Simmons (55%),[12] Seltzer and McCabe (98%),[10] Black et al (85%) and the author (85%) (unpublished data). Strohm[16] compiled the results in 216

published cases and found improvement in 98% of the cases! It is because of these remarkable success rates that physicians are encouraged to seek out patients with possible PLFs for further evaluation and possible treatment.

CASE HISTORIES

Case 1

A 28-year-old woman involved in an auto accident sustained multiple skeletal injuries, a cerebral contusion, and a right temporal bone fracture. An initial exam 6 days after the accident revealed dried blood in her right external ear canal. A subjective fistula test was not possible and caused by skeletal injuries a Romberg test was not possible. She was next seen 10 weeks later because of ataxia, positional vertigo, reading difficulties, motion intolerance, and concentration problems. Her audiogram was normal after resolution of her hemotympanum. She had a positive tandem Romberg test but her subjective fistula test was negative. Her platform fistula test, however, was positive on the right. Her ENG showed a right reduced vestibular response and her ECOG was borderline abnormal on the right. Four months after she was injured, her recovery had slowed despite physical therapy and she underwent a right perilymphatic fistula repair. Findings were a partially dislocated incus and an oval window perilymph leak. Both oval and round windows were patched. She showed slight improvement 1 month later but 6 months later she was functioning normally, with only slight positional vertigo.

Case 2

A 32-year-old woman sustained a mild head injury in an auto accident, but with no loss of consciousness or amnesia. She was released from the Emergency Room (ER) after 5 hours. She reported "feeling weird" in the ER, then spent the next week in bed at home. When she got out of bed she was ataxic. She denied vertigo but after beginning ambulation noted severe ataxia and motion intolerance. She consulted a neurologist who diagnosed postconcussive syndrome. Eleven months later her symptoms were unchanged and she was referred to the author by an internist whom the author had treated for a PLF. The patient had a right positive subjective fistula test, a positive tandem Romberg test, and a right hearing loss at 6 and 8kHz. An ECOG was borderline abnormal on the right and the platform fistula test was normal. Her ENG showed a right reduced vestibular response. She underwent repair of both oval and round windows and in 1 month she had complete resolution of her symptoms.

Case 3

A 35-year-old postman slipped on ice, striking the back of his head on a step. He denied loss of consciousness or amnesia, but the next morning he was unable to get out of bed because of whirling vertigo with nausea and vomiting. He also noted marked aural fullness on the left. The next day he returned to work but experienced waves of dysequilibrium and nausea along with motion intolerance. He, too, was diagnosed as having postconcussive syndrome and after consulting six doctors, was sent to a psychiatrist to treat his anxiety neurosis. The psychiatrist had experience with panic attack patients who had PLFs and referred the patient for an evaluation. He had a negative subjective fistula test but a positive tandem Romberg test. His left platform fistula test was positive and his ECOG was borderline abnormal on the left. His ENG showed abnormal positional nystagmus. He underwent a left repair of the round and oval windows with complete resolution of his vestibular problems, stiff neck, and anxiety neurosis.

Case 4

A 35-year-old woman nurse had undergone a previous and successful repair for a PLF of undetermined origin. Eight months later the car she was driving was struck from behind, and she sustained whiplash injury. She had an immediate recurrence of dizziness and mild neck pain. She experienced memory problems, had difficulty both reading and in solving simple arithmetic problems. Testing confirmed significant cognitive deficits. Her subjective fistula test, which had become negative following her first PLF repair, was again positive in the left ear. Her platform test was positive on the left as was the ECOG borderline abnormal. Her ENG was normal. She underwent a revision PLF repair and shortly thereafter her vestibular problems were resolved and her memory and cognitive skills improved dramatically. Testing confirmed the patient's subjective impressions.

Case 5

A 22-year-old man sustained a .38 caliber gunshot wound to the neck. The bullet struck the cervical spinal column, producing a transection in the lower cervical area. The patient remembers the immediate onset of roaring tinnitus in both ears and severe pressure in both ears. The patient was seen 4 months after the wound was incurred because he had severe and incapacitating positional vertigo. The patient was paraplegic and spent most of his time in bed. He reported severe whirling vertigo with nausea each time he changed position in bed or moved his head side to side. The vertigo was so severe he was unable to undergo any productive physical therapy. His subjective fistula tests were positive in both ears, as was his ECOG testing. His paraplegia prevented a platform fistula test, the ENG fistula test was substituted and also positive in both ears. His right ear was repaired first and he reported no change. Two weeks later he underwent a repair on the left ear. He has continued to show slow but sustained resolution of his symptoms and now participates in physical therapy activities. This case illustrates the difficulty of treating a patient with bilateral PLFs until both ears are repaired.

SUMMARY

Perilymphatic fistulas exist in patients with head injuries. Clinicians should avoid automatically assuming postconcussive syndrome in all head-injured patients who have persistent vestibular disturbances, ataxia, and cognitive/perceptual deficits. Perilymphatic fistulas are apparently a subset of chronic postconcussive cases. It is necessary to recognize the possibility of PLF because the label postconcussive syndrome often results in no agreement on treatment, pathology, or prognosis.

Finally, there are certain recommended maxims for diagnosing a perilymphatic fistula in the head trauma patient:

1. Beware of spontaneous-episodic or fluctuating vertigo/dizziness as an indication of PLF.
2. If fistula tests are negative, give the patient 6 months to recover. If significant dizziness persists, consider treating for a PLF.
3. If there is hearing loss, especially unilateral, look for a PLF.
4. Consider fistula tests of any kind as indicators of an active PLF.
5. PLFs may intermittently open and close and give variable results on diagnostic tests.
6. ECOGs with SP/AP ratios of 0.40 to 0.60 may indicate a PLF causing a mild secondary endolymphatic hydrops.

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