ERRORS IN FACIAL NERVE SURGERY

NICHOLAS J. HAMILL AND JACK M. KARTUSH

Michigan Ear Institute, Farmington Hills, MI, USA

Abstract

Surgery of the facial nerve is a difficult task. It is well recognized that difficult tasks cannot be completed without error every time, even in the most capable hands. Slips can be decreased by recognizing interruptions in routine and reviewing a mental checklist before returning to the task at hand. Mistakes can be minimized through proper training emphasizing anatomical dissection, literature review and surgical exposure. Latent errors can be exposed by analyzing the surgical technique and system design for potential pitfalls. Anticipating the potential for error is key. If an error or near miss is encountered, it should serve as a 'wake up call' prompting a failure mode analysis. The design of the system should be re-evaluated and modified to prevent future mishaps. Surgeons should take advantage of technology that can improve operating safety in conjunction with their surgical skills. Finally, a forum for sharing safety information related to near misses and error prevention should be established so that many can benefit from the mistakes of a few.

Introduction

Surgery of the facial nerve challenges even the best surgeons. All otological and neurotological procedures carry the risk of iatrogenic facial nerve injury. Often, this risk is heightened by the presence of disease or previous surgical intervention. This paper will focus upon methods aimed at reducing the potential for iatrogenic facial nerve injury.

Why do errors occur?

An error can be defined as an occasion when a planned sequence of mental or physical events fails to achieve its intended goal. Much has been learned from analysis of errors contributing to major industrial disasters, such as the space shuttle Challenger, Three Mile Island and Bhopal. It is only recently that the medical field has begun to examine the cause and cost of human error[1]. It is estimated that one million preventable medical errors result in 120,000 deaths each year[2]. Once the reality of medical errors is acknowledged, efforts can be focused on error reduction.

Address for correspondence: Jack M. Kartush, MD, Michigan Ear Institute, 30055 Northwestern Highway, Suite 101, Farmington Hills, MI 48334, USA

New Horizons in Facial Nerve Research and Facial Expression, pp. 317-322 edited by N. Yanagihara and S. Murakami
Proceedings of the VIIIth International Symposium on the Facial Nerve, Matsuyama, Ehime, Japan, April 13-18, 1997

Active and latent errors

Errors may take two forms: active and latent. If an error is readily apparent, it is considered an active error. Latent errors are those that remain hidden within a system, potentially combining with an active error to create a disaster. Using an empty soda bottle to store paint thinner is an example of a latent error. If a person confuses the paint thinner with the soda they recently opened, an active error occurs. However, the predisposing condition was the latent error of storing paint thinner in a bottle commonly used for human consumption.

In facial nerve decompression surgery, a burr skipping onto an exposed facial nerve would be an active error. Closer evaluation of the surgical procedure, however, might reveal that the mastoid segment of the facial nerve was uncovered prior to completion of all major bone work. The latent error would thus lie within the sequence of surgical steps, where the facial nerve was exposed early in the procedure. While the surgeon may routinely follow the above protocol without incurring an error, a safer alternative would be to expose the facial nerve only after all major bone work was complete. The key to latent error prevention requires anticipation of the rare problem and recognition of flawed system designs that may allow an individual to fail.

Slips

One type of active error is a slip or lapse. We experience these daily. A slip can be defined as an error that occurs during performance of a routine task. Usually a slip is made when the person is distracted from the job at hand. Once the distraction is gone, the person returns to their task but fails to mentally check their progress resulting in an error.

An everyday example is forgetting to mail a letter. A person may be leaving the house specifically to mail a letter, but upon getting their coat is interrupted by the ring of a telephone. Upon completing the phone conversation, the person grabs their keys and heads out the house, leaving the letter on the table.

In otological surgery, the surgeon may be interrupted by a question from anesthesia about the next scheduled case just as he has completed the postauricular incision. Upon returning to the case, the surgeon may place the retractors and begin elevating the tympanomeatal flap, omitting the step of obtaining fascia for the graft.

Many of our daily routines are automatic behavior arrays, such as getting dressed in the morning, driving to work or mailing a letter. If we are not interrupted, out routine usually goes smoothly. If an interruption is introduced into the routine, however, the possibility for an error increases. Upon returning to the task at hand, we risk omitting a key step with a resulting error if we do not mentally check our previous progress. The message here is that we can reduce the risk of error by associating interruptions in our routine task performance with a need to intentionally refocus upon our return.

Mistakes

Another type of error is a mistake. A mistake differs from a slip in that we are actively trying to solve a problem but fail in planning and judgment. The inexperienced and poorly trained are most susceptible to mistakes.

An example is that of playing chess. A novice may have only a handful of memorized defense strategies. If confronted with a novel attack, the novice may employ an ineffective defense resulting in capture of his queen. An experienced chess master, however, would recognize the attack sequence and choose an effective defense.

In operating on a congenitally anomalous ear, an inexperienced surgeon may not anticipate the presence of a laterally displaced facial nerve. If a routine canaloplasty is performed based on where the facial nerve ought to be, the anomalous nerve may be injured. The more experienced surgeon, however, would recognize the potential for an anomalous nerve and employ an alternate technique. Anticipation, experience and training are thus the keys to minimizing mistakes.

Training

Mistakes are out best teachers. The most experienced surgeons have learned from their previous mistakes. The young surgeon can benefit from this wisdom during their training, incorporating and establishing safe techniques from the beginning. Proper instruction, extensive literature review and anatomical dissection are prerequisites for a successful surgeon. Depending upon the surgical case and volume and variety, residency training may be enhanced through a fellowship experience. The better trained a surgeon is, the greater experience obtained and the less likely mistakes will occur.

The anatomy of the facial nerve is complex and has been the subject of many articles and texts. All surgeons must master the anatomy of the region within their specialty. In a review of iatrogenic facial nerve injuries, it was apparent that a lack of familiarity with temporal bone anatomy contributed to injury in many cases[3]. Repeated practice in the temporal bone lab is the key to appreciation of the subtleties of critical anatomical structures. It is only through repeated study of the normal anatomy that the surgeon effectively prepares for the more challenging task of operating in a diseased, previously operated or anomalous ears.

Facial nerve monitoring

Although monitoring techniques have improved facial nerve preservation in neurotological surgery, its benefit in chronic ear surgery is less well established. The potential benefits are readily apparent, as the majority of facial nerve injuries in chronic ear surgery are not detected at the time of surgery[4]. Monitoring is not a replacement to surgical knowledge and skill. Indeed, relying on monitoring in the absence of adequate training is dangerous. Similarly, the surgeon must have a full understanding of the monitor employed to avoid potential pitfalls and properly interpret information obtained from its use. Adequately trained, the surgeon can use the monitor to his advantage as a passive and active instrument. Passive monitoring can recognize early thermal injury, traction injury or direct trauma to the nerve. Active monitoring with stimulating dissection instruments affords localization of the facial nerve in tumor and diseased states prior to and during surgical manipulation.

Specific techniques

Local anesthesia

Injection of local anesthetic is avoided over the mastoid tip. Overzealous injection in this region can result in conduction block of the facial nerve. Although this is a temporary phenomenon, it would render intraoperative nerve monitoring useless.

Incision

The facial nerve is most superficial as it exits the stylomastoid foramen, especially in children. Even at a low setting, the potential for injury from the shunted electrocautery current is a concern. For chronic ear surgery, most surgeons create a curvilinear postauricular incision in a classic 'C' shape. We prefer a modified incision where inferiorly it is placed more posteriorly over the mastoid tip, ending approximately 1.5 cm behind the lobule. By modifying the incision and avoiding the Bovie inferiorly in favor of the bipolar, risk to the facial nerve is reduced. Exposure from this modified incision is unchanged.

Drilling

Safe drilling techniques can minimize inadvertent injuries. All available anatomical landmarks are used to ensure proper orientation. Bone removal is performed with adequate irrigation to avoid thermal injury to the facial nerve. Drill strokes are parallel to important structures. If the drill begins to vibrate, its orientation is changed and the area is further saucerized. If vibration continues, the drill bit is switched to either a smaller cutter or the same sized diamond. Cutting burrs are expedient, but carry the risk of skipping if a bony ledge is contacted. Bony ledges are approached from the side, thinning them rather then placing the burr directly on the edge.

If exposure of the facial nerve is required, all surrounding bone work is completed before the nerve is exposed. This prevents a skipping burr from inadvertently injuring a facial nerve. An example is the technique of labyrinthectomy en route to acoustic neuroma resection in the translabyrinthine approach. Commonly, the facial recess and incus are removed prior to labyrinthectomy. In our hands, the labyrinthectomy is competed prior to removal of the incus and opening of the facial recess. In this case, if the drill skips over the horizontal semicircular canal, the incus and closed recess prevent the burr from rolling onto the tympanic segment of the nerve. Similarly, the technique of labyrinthectomy is altered from the standard approach. Most surgeons begin drilling over the horizontal canal demonstrating the blue line before proceeding with the labyrinthectomy. We prefer initially to preserve the horizontal semicircular canal. By starting drilling over the subarcuate fossa, a cup of bone is created. The horizontal canal is then opened from the superior aspect. If the burr skips, its position is maintained within the protective cup of the bone, further protecting the facial nerve or dura.

Intraoperative monitoring

As previously stated, both passive and active monitoring are employed. The facial nerve is at most risk in states of disease where anatomy is anomalous, obscured or exposed. **Stimulating dissection instruments are used with current adjusted based on the magnitude of response once the nerve is identified**. The stimulating instruments are beneficial in recognizing an attenuated nerve in tumor cases as well as dehiscent nerves in chronic ear surgery. In tumor surgery, prior to tissue debulking, the area is mapped with the stimulating instrument to assure that that the facial nerve is not in the area. In chronic ear surgery, before sweeping cholesteatoma from the facial recess or tympanic segment, stimulating instruments are used to identify any exposed nerve that would be at risk from surgical manipulation. Stimulating instruments also allow direct stimulation when dissecting tumor or cholesteatoma from a dehiscent nerve.

As with any tool, potential pitfalls must be recognized. False responses (artifacts) may occur due to (1) static or (2) overcharging of the monitor's capacitors from electrocautery. Static from contact between metal instruments will cause the monitor to alarm. The waveform can be distinguished from a true facial nerve response by its characteristic appearance on the oscilloscope screen as a single, abrupt electromyographic response[4]. Similarly, as charge builds up from the electrocautery use, the monitor may constantly alarm when the stimulating instrument is used (dc offset). This again is recognized by the characteristic appearance of the oscilloscope screen as a dc shift of the electromyographic baseline. By first contacting tissue distant from the facial nerve, the surgeon can predict the presence of dc offset and static artifact if the alarm sounds. This problem is corrected by turning the monitor off for a few seconds. Finally, the surgeon must remember that the monitor is sensitive enough to pick up masticator muscle activity. If the pars minor of the trigeminal nerve is stimulated, the monitor will sound from the masseter contraction. The surgeon must recognize this potential when stimulating during dissection of CPA tumors, trigeminal nerve surgery or vestibular nerve surgery to avoid confusing masticator contraction with a facial nerve response.

Laser

The laser has been a significant technological advantage in otological surgery, improving results in small fenestra stapedectomy and minimizing trauma to the ossicles when dissecting disease. Direct laser injury or transferred heat to the facial nerve must be avoided. Recognizing this, we place a suction tip or a piece of moist gelfoam between the surgical site and the facial nerve as a protection against an aberrant laser strike. The suction also provides a cooling effect by removing the hot plume. If extensive laser use is employed, irrigation is also used to cool the field.

Hemostasis

Hemostasis is vital to successful neurotological and otological surgery. Bovie cautery is used away from the facial nerve, but bipolar cautery is used when close to the facial nerve in order to minimize spread of both thermal and electrical energy through soft tissues. For bleeding directly on the facial nerve, we prefer to use adrenaline or thrombin soaked gelfoam for hemostasis. Bipolar cautery can be used in tumor surgery after neural mapping with stimulating instruments. When cautery is employed near the nerve, the wound is frequently irrigated.

Acoustic neuroma (specific techniques)

In acoustic neuroma surgery, we frequently decompress the meatal foramen at the time of resection[5]. As this is the narrowest segment of the bony course of the facial nerve, decompression minimizes delayed facial palsy due to postoperative edema. We perform this decompression prior to opening the internal auditory canal, using a small diamond burr and intraoperative monitoring. The bone over the meatal foramen and labyrinthine segment has a characteristic yellow appearance as one approaches the nerve, providing the surgeon with an anatomical clue of its position. Further, as the geniculate ganglion is approached, sentinel bleeding is often apparent.

The importance of tumor mapping with stimulating instruments has been previously discussed. As tumor is dissected away from the facial nerve, care is taken to avoid suction directly on the nerve. Brackmann fenestrated suctions can be helpful. When dissecting tumor, traction is minimized and recognized when present through facial monitoring. When tumor removal or debulking is performed, the tumor is gently pulled away from the facial nerve before using the bipolar or laser.

The facial nerve is at significant risk following tumor removal when it is exposed and freely floating in CSF. We take care to exercise continued caution at this time, when intuitively some of the pressure is off the surgeon. As the CSF is suctioned to minimize pressure during closure, an instrument is placed adjacent to the suction to avoid the possibility of suctioning the exposed nerve. Similarly, as the abdominal fat is placed during translabyrinthine procedures, careful attention is paid to the nerve monitor to detect any evidence of traction potentials.

References

1. Brennan TA et al: Incidence of adverse events and negligence in hospitalized patients: results of the Harvard Medical Practice Study 1. N Engl J Med 324:370-376, 1991
2. Leape LL, Lawthers AG, Brennan TA, Johnson WG: Preventing medical injury. Qual Rev Bull 19:1440149, 1993
3. Green JD, Shelton C, Brackmann DE: Iatrogenic facial nerve injury during otologic surgery. Laryngoscope 104:922-926, 1994
4. Kartush JM, Bouchard KR: Intraoperative facial nerve monitoring in otology, neurotology and skull base surgery. In: Kartush J, Buchard K (eds) Neuromonitoring in Otology and Head & Neck Surgery. New York, NY: Raven Press Ltd 1992
5. Kartush JM, Graham MD, LaRouere MJ: Meatal decompression following acoustic neuroma resection: minimizing delayed facial palsy. Laryngoscope 101:674-675, 1991