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# Are we getting alarm fatigue from the facial nerve monitor?

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## ABSTRACT

### Objective:

To study the frequency of alerts from facial nerve monitors during otologic surgery.

Design: Prospective series

Setting: Tertiary referral center

Patients: Surgical cases involving any type of ear surgery

Intervention: Diagnostic

Main Outcome measure:

Each of 55 otologic cases was monitored in a standard manner with the NIM-3 facial nerve monitor and the alerts were recorded. After each case, the file was downloaded and the alert recordings were transferred to an Excel spreadsheet. The individual stimulation alerts were grouped into events and the frequency was analyzed.

### Results:

Monitoring was performed for a total of 8107 minutes and there were an average of 18.4 stimulation events per case. This is an average of 6.9 stimulation events recorded every hour of surgery. No case had a facial nerve injury and most events were 'false alarms'.

### Conclusion:

The facial nerve monitor might be causing alarm fatigue. The alarm sound frequently and most alerts are not associated with injury to the facial nerve. A comparison with other alarm systems indicates that the frequency of alerts is high enough with the NIM-3 that it may be a source of alarm fatigue. Other observations associated with monitoring were made as a result of the study.

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## INTRODUCTION

Surgeons are exposed to many alarms in an operating room. Otologists are exposed to a specific surgical alarm, the facial nerve monitor. The idea of the monitor is to alert the surgeon when the nerve might be at risk for injury. Immediate feedback from the monitor to the surgeon improves facial nerve outcomes in cases of acoustic neuroma surgery(1). A recent survey suggested that many otologic surgeons use a facial nerve monitor for chronic ear cases(2, 3). Papers have stressed the advantages of monitoring facial nerve function but there is no agreement whether the monitor is a standard of care. The risks and pitfalls of monitor use have been minimized. Opponents to facial nerve monitoring have stressed that the safety of the facial nerve can be positively affected by familiarity with anatomic landmarks. Rates of injury from chronic ear surgery have been reduced to extremely low levels with improvements in visualization, anatomic teaching, and careful instrumentation. Opponents to monitoring have stressed that the alarm does not stop a surgeon from cutting through the nerve. Kartush has emphasized using a monitor correctly and stressed the importance of using a protocol(3).

This study was initiated to look at one of the downside issues from the use of facial nerve monitoring. All forms of monitoring an alarm can create what has become called alarm fatigue. Sometimes this is referred to as a 'cry wolf' effect.(5) As the name suggests, if an alarm is too often false, the real alarm is ignored. If an alarm sounds frequently, the person that is supposed to respond to the alarm no longer considers it to be important or a valid alarm possibly ignoring a true alert. The purpose of our study was to examine the number of stimulus reports during surgery for all types of ear cases. We present the data collected and suggest that some degree of alarm fatigue appears likely in our operating room.

Alarms in other areas of medical practice have become associated with alarm fatigue(4). Alarms are used in many complex settings and aviation has studied the effect of frequent alarms.

At our institution, it is part of the ear surgery protocol to use a facial nerve monitor. We studied the alarm results in patients who were undergoing surgery for various otologic problems. Our institution uses the Nerve Integrity Monitor -3 from Medtronic (Minneapolis, MN). While it is not the only device available for monitoring the facial nerve's function, it appears to be a commonly used device. The monitor is supposed to sound an alarm if a muscle twitch is detected. Each time that the recording electrodes showed a current outside of the resting range that suggested that a stimulation occurred, it sounds a beep tone and records the event in memory.

The alarm can either be a beep or enunciate an 'attention' statement. One of the features of this monitor is that it can record the stimulation events during a case and will prepare a report that can be downloaded. We looked at the number of alarms being sounded during an entire case.

# Beep Beep!!



## METHODS AND MATERIALS

All of the patients having ear surgery at the University medical center usually have facial nerve monitoring. This particular monitor also has a threshold adjustment. We follow the manufacturer's recommendations. All cases were monitored during the six-month study period included in this study. The study was completed from July 1, 2014 through December 31, 2014. The surgeon used only epinephrine injected at a dose of 1:100,000 or applied on topical gelfoam at 1:1,000. No lidocaine was used since a general anesthetic was used for all cases. In all cases the patient received an anesthetic that avoided the use of any long-acting muscle relaxants. Some patients received a short acting agent to enable intubation without difficulty. When a short acting agent was used, restoration of normal muscle activity was confirmed with a stimulator on the hand showing 4 twitches. In all cases the orbicularis oculi and orbicularis oris were used for monitoring. The impedances were checked and found to be within the accepted limits for the machine prior to prepping for surgery. All of the cases were tap tested and were recorded to indicate that there was in fact an EMG that could be recorded. In all cases, the surgeons monitored facial nerve function. Events that exceeded 100 micro-volts were recorded. At the conclusion of the surgical case before the monitor was turned off, the data was downloaded in a CSV format for transfer to the Excel spreadsheet. For a small number of cases the downloaded data was corrupted or the monitor was powered down without the data getting to a drive and therefore the data could not be used. For each entry line on the spreadsheet, the monitor would give the time, stimulator setting and if the stimulator was contacting the patient, the voltage in the EMG pairs, and the event threshold that was used for triggering a beep and the recording of that line. The surgeons rarely used the monitor's incorporated electrical nerve stimulator and events where the electrical stimulator was used were recorded separately. Because of repeated recorded beeps occurring many times per minute, these were lumped together for this analysis into a single stimulus event. If less than ten seconds passed between stimulations, they were lumped into what we will call a stimulation event. If more than ten seconds passed before another recorded line on the monitor, it was a different event. Data was collated and de-identified according to the IRB approval requirements for this quality improvement study. During the study period there were no incidents of postoperative facial paralysis.

## RESULTS

A total of 55 cases were successfully recorded and analyzed. The cases encompassed a wide range of otologic cases since it was used for stapedotomy, tympanoplasty, cochlear implants and all mastoid cases. A total of 8107 minutes of surgery was recorded. When examining the individual beep or alert lines on the spreadsheets, there was a wide range of individual lines in a given case. The line count for a given case ranged from a low of 4 to a high of 1897 lines recorded for a single case. Reducing the lines to events gave 1028 stimulus events that occurred during all cases. The average case was 2 hours 24 minutes. **The average number of recorded stimulation events was 18.37 events per case or 6.3 events per hour.** There was a wide range of events per case.

## DISCUSSION

There was a significant number of stimulation events recorded during the surgical procedures. A majority of the events did not correlate with any surgical stimulation of the facial nerve. Some events were clearly artifact created from a number of sources. Some of the artifact was electrical from dissimilar metals contacting the patient. Electrodes were bumped during handling of instruments. We did not record specifically if the nerve was stimulated by cold irrigation or bumped by a blunt surface of a surgical instrument although the surgeon may have noted it. The recording function on the monitor did not differentiate whether it was an artifact, movement or a surgically induced stimulation. We sought guidance from the monitor maker's technical staff and they confirmed that looking at the lines of recordings, it is impossible to tell the source of the recorded event. It recorded any time that the machine identified a current that met criterion for an alarm whether real or artifact. Discussion with the technical staff at Medtronic led us to believe that it was not possible to apply any algorithm to sort out EMG from artifact. Immediately following the conclusion of this study, Medtronic released a software upgrade for this monitor to minimize artifact.

Anesthesia plays a role in these cases because depth of anesthesia controls movement. The anesthesiologist and anesthesiologists rotate on a daily basis at our institution. The patients' age also covered a wide range. Some were healthy young adults and others sick elderly patients with substantial anesthetic risks. We did not correlate the anesthesia risk and the monitor outcomes in this study. The IRB approval did not provide for the opportunity to examine charts after the study and we did not record the anesthetic risk score in any way. In some cases, the patient's anesthetic became light and the facial nerve was firing as a result of inadequate anesthesia to stop motion. Without a muscle relaxants there were some cases where facial movement and even body movement occurred. Patient age was not analyzed. Because of monitor use, the anesthesia team did not use muscle relaxants. This affected their agent selection and their ability to keep patients motionless. The motion recorded by the monitor might be better correlated with the depth of anesthesia than to potential facial nerve injury. Similarly, advocates for general anesthesia in ear surgery sometimes list the lack of motion as an advantage to general anesthesia. Because the patient is not receiving a muscle relaxant, they can and do move. We did not record the number of times that patients moved during the cases that were recorded. Movement alone would seem to increase the risk of injury to the facial nerve but it was not observed in this study.

It is hard to put in context what it means to have an average of six alarm events per operating hour. Alarm fatigue has been observed in other fields like monitoring of pipelines, ICU alarms and aircraft operations. Nursing considers the alarms on medication pumps and O2 saturation monitors to be particularly prone to alarm fatigue (4, 6). These studies have cited false alarm rates over 80% and some as high as 99%. The best studies of alarm fatigue seem to be from the aircraft industry and the FAA. Reports of airplane crashes have outlined how an alarm was sounding and the actions taken or not taken by the pilots. Not uncommonly they have misidentified which alarm was sounding and taken inappropriate actions because of this. Sometimes they have misinterpreted the changes that set off the alarm. Because the incidence of facial weakness is so low, we would have to examine many more cases to see an unfavorable event. We did not see unfavorable outcomes in only 55 cases and based upon other otologic reports, the rate of injury should be less than 1:1000 cases.

Was the alarm ignored because of alarm fatigue? The false alarm rate in other areas is better studied. The FAA has carried out studies of alarm systems with air traffic controllers and there is evidence that when the rate of false alarms exceeds 60%, people stop paying attention to the alarm and have slower response times to taking action(5). They saw no response in 10-20% of the alarms. This effect could only be measured with perhaps ten times the number of cases used in this study. Still, this study raises the issue of how many alarms sound in an operating room and do they really improve outcomes. Outcomes in acoustic neuroma surgery have been improved by the use of a facial nerve monitor(7). Have we reduced the number of facial nerve injuries in other areas of ear surgery by using the monitor(8, 9)? The data collected is less clear. There are no randomized studies and the power needed to see this change is significant.

## CONCLUSIONS

1. The NIM-3 Alarm sounds too often during chronic ear surgery
2. The monitor usually sounds a false alarm
3. The surgeons sometimes cannot tell it apart from other alarms in the OR
4. Too often, surgeons ignore the monitor

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