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Cellular Telephone EMI with Ventilators and Power Wheelchairs

by Ian Denison

Executive Summary

I was asked to carry out an empirical study and observe for interference between cell phones and both power wheelchairs and ventilators at GF Strong site under worst case conditions.

Typically a hand held phone in the old building at GFS starts out transmitting at 0.6 w (watts) and within 30 seconds transmissions reduce to 0.1 w or less. In the new building the phone may continue to operate at 0.6 watts due to the signal attenuating effects of the concrete structure.

All hand held cellular phones are capable of a maximum transmitting power of 0.6w.

Car phones and most transportable bag phones transmit at a maximum power of 3 w.

Sixteen (16) power wheelchairs and three (3)-Aequitron LP6 Plus ventilators were tested.

All tests initially re created a worst case scenario i.e., one in which the phone transmits at 3w in contact with the device being tested. If the device malfunctioned the test was repeated at increased separation and reduced power settings and the results recorded.

A few of the older wheelchair controllers proved to be susceptible to very high levels of electomagnetic energy. The electromagnetic brakes on the motors could be released under certain circumstances.

At 3 watts we were able to cause autocycling in the ventilators (the airway pressure sensor assumes a breath is being initiated and delivers a breath) from as far away as 64" on one model and 42" on another. At 0.6 watts the antenna had to be within 24" of one model to trigger autocycling and in contact with another unit. We could stop one ventilator from a distance of 9" and 5" when

transmitting at 3w and 0.6w respectively.

In all cases the vents resumed normal function when the signal was terminated.

We can not lose sight of reality in our zeal to protect our clients from the effects of EMI produced by cellular phones. The very people we are trying to protect from cellular emissions are the ones with the most to gain from the independence which portable communications offer. The reality is that cellular phones are out in the community in large numbers (500,000 in BC) and this, after all, is where we want our clients to live.

Education is the key to optimizing safety, educating the client and their families, letting them experience what can happen, and how to deal with the situation.

In order for us to reduce the risk to our clients we must:-

- Develop policies based on the recommendations made in this report.
  Acquire a programmable cellular phone. (Adjustable power level in both analog and digital modes.)
- Establish information / education sessions for staff and clients.
- Develop signage
- Develop a fact sheet to educate third parties.
- Establish a mechanism for reporting and investigating unusual behaviour of medical equipment.
- All specifications for new sensitive equipment should contain an EMC clause.
- The cost of these measures is not expected to be significant.

A ban on cell phones at GF Strong does not prepare our clients for life in the Community.

The test results suggest that most of the devices are adequately shielded against the EMI emitted by most phones. Where special risks exist these should be identified and specific measures taken to reduce the risk to individual clients.

Introduction

During a recent meeting of the Executive Management Team (EMT) of BC Rehab concern was expressed about the effect Electromagnetic Interference (EMI) might have on some of the medical equipment in use at our facility.

I was asked by Dr John Higenbotham to do a quick analysis of the problem and report back to him within two weeks. At that time we decided that we should focus our investigation on the effect EMI had on power chairs and ventilators.

Scope

Carry out an empirical study and observe for interference, under worst case conditions, for both power wheelchairs and ventilators at GF Strong site.

Literature Review

With the help of Simon Cox from the Kinsmen Rehab Foundation and Doug Gayton from the Assistive Technology Service, I was able to source a number of documents dealing with the issues of Electromagnetic Compatibility (EMC).

There is no doubt that EMI produced by Radio Frequency Transmitting Devices (RFTD) has the potential to trigger responses from medical devices ranging from pacemakers to infusion pumps and wheelchairs to ventilators.

Ad hoc or empirical testing is a valid way to guage EMI provided that the transmitters power level could be pre set.

No format for ad hoc testing has been developed although Dr Bernard Segal of McGill University is working on a draft set of standards.

Background

Cellular phones use low power radio waves to transmit and receive telephone calls. Regions are divided into cells each served by a transmitter / receiver tower. In urban areas, each cell may be further split into three sectors of 120

degrees each. Calls to and from cell-phones are routed from the tower into the land-line telephone network. As a caller moves about, the signal from the telephone is automatically handed off to the nearest cell site. During a call, the cell site is capable of controlling the cell-phone's transmitter power, setting it to the minimum value required for reliable communications. This produces three benefits:

- It minimizes interference between cells

  Reduces the potential for EMI.

What this means is that people in urban coverage areas are often close enough to a cell-site so that their transmitted power will get stepped down to a fraction of the set's maximum capability. While they may be bombarded by a high level of ambient electromagnetic energy compared to their counterpart in a less densely populated area they are not getting exposed to the relatively concentrated EM energy required to transmit a call from their phone to a distant cell.

There are three modes of cellular communication commonly available in BC. Analog, TDMA digital and CDMA digital. The literature indicates that Analog transmissions have a bigger impact on medical devices with the exception of pacemakers, which are more easily affected by TDMA due to the modulation frequency, which is 50hz.

Typically a hand held phone in the old building at GFS starts out transmitting at 0.6 w (watt) and within 30 seconds is transmitting at 0.1 w or less. In the new building the phone may operate at 0.6 watts due to the signal attenuating effects of the concrete structure.

All hand held cellular phones are capable of a maximum transmitting power of 0.6w.

Car phones and most transportable bag phones transmit at a maximum power of 3 w.

It is a further practice of cellular phone companies to program most of their urban sites to instruct cell-phones to begin every call at the 0.6-Watt level, putting 3- and 1.5-Watt sets on an equal basis with the maximum power of a hand-held phone.

The intensity of propagated electromagnetic energy obeys the Inverse square law. i.e., If you double the distance between yourself and a transmitter the EM energy that you are exposed to is quartered. Unfortunately this only really applies to the Far field (3' to infinity) rather than the near field (0 to 3') that applies in most of our situations.

Testing equipment

(Provided by Peter Trellis from BC Cellular Mobility)

Oki transportable phone. Transmitting power determined by the tester.

- Type Analog
- Max power 3 watts
- Approx frequency 850 Mhz

A Trifield meter to confirm the phone was transmitting.

Subjects

- 12 E and J Xcaliber power wheelchairs with Z61 controllers.
- 2 Permobile Power wheelchairs.
- 2 Invacare Arrow power wheelchairs (1 - Mk I controller and 1 - MkIII controller).
- 3 Aequitron LP6 Plus ventilators.

Testing Methodology

<u>Wheelchairs</u>

Tested at both the joystick and main controller, if supplementary controllers were mounted these were also tested.

The phone was set to it's highest power setting.

The wheelchair was turned on.

The antenna was then placed in contact with the housing of the component being tested and the orientation of the antenna rotated through 180 degrees.

This was repeated on all sides of the component.

The wheelchair was then driven to see if the EMI from the phone interfered with it's operation.

If any effect was produced it was noted and the phone pulled away until no response was noted.

The power was then reduced and the tests repeated until no response was elicited from the component under test.

Ventilators

The breathing effort was set to -0.5cm H_2O.

The phone was set to its highest power setting.

The vent being tested was turned on.

The antenna was then placed in contact with the housing of the ventilator and the orientation of the antenna rotated through 180 degrees.

This was repeated on all faces of the vent.

If any effect was produced the phone gradually pulled away until no response was noted.

The power was then reduced and the tests repeated until no response was elicited from the component under test.

Miscellaneous

In addition to wheelchairs and ventilators, I also tested a number of devices commonly recommended by our Assistive Technology Service:

- Lightwriter
- EasyTalk
- Epson HX20 Real Voice
- Fred

- Tash Ultra 4

These augmentative communication and remote control devices were tested in a similar fashion to the vents and wheelchairs, but only in their most sensitive orientation relative to the antenna.

Results

Wheelchairs

I was only able to cause some automatic brakes to disengage if all of the following criteria were met:-

- Phone transmitting at the maximum 3 watts.
- The antenna is very close to the controller.
- The orientation of the antenna is exactly right.
- The controller is pre 1994.

Ventilators

3 watts

We were able to cause autocycling (the airway pressure sensor assumes a breath is being initiated and delivers a breath) from as far away as 64" on one unit and 42" on another. The effect could also be produced through the wall between the corridor and the client rooms .

We were also able to cause one vent to stop functioning when the antenna was held within 9" of the base of one unit.

0.6 watts

The antenna had to be within 24" of one unit to trigger autocycling and in contact with another unit. We could stop one ventilator from a distance of 5".

In all cases the vents resumed normal function when the signal was terminated.

A quick test performed on a Bear ventilator revealed that the vent could be made to autocycle with the phone almost in contact with the device, when it was transmitting at 3 watts. It could not be made to go "vent in op".

The metal construction of this ventilator probably accounts for its higher immunity to EMI.

Augmentative Communication devices

3 watts
Any distance less than 16" from the Easytalk rendered it inoperable.

0.6watts
No effect on the Easytalk.

Both the Lightwriter and the Epson HX20 RealVoice remained functional but experienced background noise that increased with transmitting power and proximity to the antenna.

Remote Controls

3 Watts
The Tash Ultra 4 failed to respond with the phone placed within 12" of the receiver.

0.6 Watts
Failed to respond with the phone placed within 6" of the receiver

The Infrared RC FRED was not affected.

Discussion

Perhaps one of the most interesting aspects of this issue is that if we don't hurry up and do something, the problem will go away. Some cellular operating companies are moving to the new CDMA digital technology for which the transmitted power levels are one-tenth to one-twentieth that of traditional technologies. At the same time, the manufacturers of sensitive devices are developing shielding and alternative technology that is not sensitive to EMI.

In the meantime we are faced with a situation that has too many variables for us to make reliable predictions:-

The three ventilators tested were identical current units, made in the same

facility and assembled to the same specifications as each other and yet their sensitivity to EMI was quite varied.

The Aequitron engineer that I spoke with tells me that the LP6 (not tested but discussed in the literature) does not have any shielding built in. The LP6 plus that we use is shielded against Electrostatic discharge (EST) which provides some EMI protection. The engineer says that slight variations in the assembly have a significant impact on EMI susceptibility.

The ventilators sensitivity to EMI induced autocycling is directly proportional to the breathing effort setting. Clients have this setting adjusted to their particular needs, which change with time.

The power output of the phone varies and all the interference that we were able to generate occurred in the "near field " i.e., within 5 feet of the transmitter. As discussed previously electromagnetic intensity varies unpredictably in this area.

Finally, orientation of the antenna to the sensitive device contributes to the EMI.

Recommendations

Our clients are going to be subject to significant cellular emissions in three instances.

- From a phone mounted to their chair.
- From nearby person receiving or making a call.
- While travelling in a vehicle fitted with a car phone.

<u>Phone mounted to wheelchair.</u>
The technician / clinician should have a transmitter available that can be preset to transmit at a high power setting or arrange for a worst-case test by a qualified technician to enable them to assess sensitive areas.

The client should be told about the possible consequences of EMI and if possible these should be demonstrated on the clients own equipment.

The client should have a means to immediately turn the cell phone off.

When selecting a cell phone to fit to a wheelchair the clinician / technician should consider choosing one that produces the minimum power for the clients needs. Hand held units (max 0.6w) are available with hands free kits and remote antenna that can be mounted away from sensitive devices.

Nearby person

The technician / clinician should have a transmitter available that can be preset to transmit at a high power setting or arrange for a worst-case test by a qualified technician to enable them to assess sensitive areas .

The client should be told about the possible consequences of EMI and if possible these should be demonstrated on the clients own equipment.

Safe distances should be established using the aforementioned test.

Sensitive devices should not be placed close to walls where a cell phone might be operating on the other side.

Signs around the building should advise people of the possible consequences indicating that people using a cell phone remain at least 6 feet away from any critical equipment attached to a client while making a call.

Vehicles

The client should be educated about the possible consequences of EMI and if possible these should be demonstrated on the clients own equipment.

Possible consequences of using a cell phone should be explained to the operator of the vehicle and a contingency plan established.

General

In order for us to follow these recommendations and reduce the risk to our clients we must:

- Develop policies based on these recommendations.
- Acquire a transportable cellular phone that we can programme to transmit at pre set levels in both analog and digital modes. (Tests employing a cell-phone in this manner must be strictly controlled because random transmissions on active cellular frequencies can ‘jam’

cellular customer's calls.)

- Establish information / education sessions for staff and clients.
- Develop signage
- Develop a fact sheet to educate third parties.
- Establish a mechanism for reporting and investigating unusual behaviour of medical equipment.
- All specifications for new equipment should contain an EMC clause.

Summary

We can not lose sight of reality in our zeal to protect clients from the effects of EMI produced by cellular phones. The very people we are trying to protect from cellular emissions are the ones with the most to gain from the independence which portable communications offer. The reality is that cellular phones are out in the community in large numbers (500,000 in BC) and this, after all, is where we want our clients to live.

Education is the key to optimizing safety, educating the client and their families, letting them experience what can happen, and how to deal with the situation.

While it is quite possible that accidental autocycling of a ventilator could occur, the more serious complete shutdown is very difficult to trigger. It is more likely to be caused by an associate of the client than a passing phone user since the antenna has to be within 5" of the base of the vent.

A ban on cell phones at GF Strong does not prepare our clients for life in the Community. By banning cellular phones within BC Rehab we are implying that the equipment used by our clients is unsafe in the presence of EMI generated by cellular phones. Then we organize recreational outings and discharge the clients into the community with the same equipment.

The test results suggest that most of the devices are adequately shielded against the EMI emitted by most phones. Where special risks exist these should be identified and specific measures taken to reduce the risk to individual clients.

In the meantime we should implement the recommendations outlined in this

report. Monitor developments and research being carried out by other organizations, share our results and take appropriate measures as circumstances warrant.

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