Radiation Safety Institute of Canada
Institut de radioprotection du Canada

WWW.RADIATIONSAFETY.CA
1-800-263-5803
info@radiationsafety.ca

NATIONAL EDUCATION CENTRE
100 Sheppard Ave East, Suite 760
Toronto, ON M2N 6N5
Phone: (416) 650-9090
Fax: (416) 650-9920

NATIONAL LABORATORIES
102-110 Research Drive
Saskatoon, SK S7N 3R3
Phone: (306) 975-0566
Fax: (306) 975-0494

EMF and Implantable Medical Devices Webinar Q&A

These are questions we did not get the opportunity to answer during the webinar. Please note, the answers below are based on our readings and experience and are not legal or medical advice.

Q: With upcoming technology, some talk has emerged about making tritium fueled batteries to power pacemakers. What kind of safety precautions are customary for devices like this, which would emit radiation into the body if not properly handled?

A: The idea of nuclear- or radioactivity-powered pacemakers is not new. Over the years, various power sources have been used for pacemakers, including radioactive materials such as Promethium-147 and Plutonium-238. Scholarly articles on this topic date as far back as 1970. In fact, the Los Alamos National Laboratory website (Facts about pacemakers (lanl.gov)) indicates that there may still be people alive in the United States, who have a Plutonium-238 powered pacemaker.

Tritium is one of the potential new sources being talked about for powering pacemakers. Tritium, an isotope of Hydrogen (Hydrogen-3 or H-3) decays to stable helium (He-3). This means that the only radioactive emissions will come from the decay of tritium itself, because the daughter atom (the resulting atom after the tritium atom decays) is not radioactive.

Beta particles emitted by Tritium during its decay have a maximum energy of approximately 19 keV and an average energy of about 5.7 keV (an eV is a measure of energy, on the atomic level). The very low energy of tritium's beta particles means that they do not travel very far in matter. They can travel up to 0.5 to 1.0 cm in air, depending on the reference, but in liquids and solids, they do not travel far at all. In water, their maximum range is approximately 0.001 cm, and in stainless steel, they travel approximately 0.06 µm, or approximately 0.000006 cm.

The extremely small distance travelled by these beta particles means that if tritium is enclosed in a battery with a metal exterior surface, the beta particles will not be able to leave the battery to interact with living tissue. The radiation emitted would stay within the battery itself. As a result, there would not need to be any specific safety precautions for protecting a person from radiation from the tritium powered pacemaker, as long as the battery is properly sealed to keep the tritium inside it. This is no different from controls needed to protect the pacemaker wearer from the contents of existing pacemaker batteries: the current "ordinary" batteries used for pacemakers (typically lithium iodide) need to be well sealed so that the chemicals within the batteries do not leak outside of it into the body.

Disposal of the batteries would also need to be controlled, as is currently required for "ordinary" pacemaker batteries. As tritium-powered batteries would still have some radioactive tritium within them when their time within the patient is over, hospitals would need to ensure that such batteries are properly managed and disposed of after being removed from a patient. This is similar to the controls needed for lithium batteries that are no longer used, although the end point for disposal will likely be a different location. Similarly, tritium batteries would need to be removed from a deceased

patient prior to the body undergoing cremation, as is done now for lithium batteries – both would create hazards to the workers in such facilities, if the batteries were subjected to the very high temperatures of cremation.

Since this talk is about EMF, it would be important to note that EMF could potentially affect a pacemaker regardless of the type of battery, depending on the amount of metal in the device, and also depending on how the device senses and reacts to currents (e.g., senses induced currents in the leads of the device).

Q: What are the concerns surrounding implanted medical devices such as pacemakers and sources of EMF such as induction cooktops?

A: In induction cooktops, coils in the cooktop produce time-varying magnetic fields that create currents in the bottom of certain types[1] of pots or pans, thereby heating the pot or pan itself (as opposed to heating the actual cooktop which then transfers the heat to the pot or pan). Such magnetic fields are usually quite strong close to the stovetop, where the base of the pot/pan would be located, then dissipating very quickly with distance (if you double the distance, the strength goes down by a factor of 4).

If a medical device is close enough to the cooktop when active, the stovetop's magnetic fields could, in theory, also induce a current in metal parts of a medical device, for example, in the metal leads of the pacemaker or possibly within the circuitry of the pacemaker or insulin pump, itself.

In a pacemaker, for example, such induced currents would not damage a person's heart, but could be detected by the pacemaker. As a result of sensing these currents, the pacemaker may not deliver any of the pacing therapy, at least for a short period. Most pacemakers will detect that this current is electrical noise and will switch to a non-sensing mode during which the pacemaker will continue to deliver the pacing treatment. If a person is fully dependent on the pacemaker, the induced currents may result in a short period of feeling slightly dizzy. Such effects, if they occur, are usually quick and dizzy spells should pass without resulting in a fainting episode. Persons not fully dependent on the pacemaker are unlikely to notice anything.

Many other common items can also create fields that may affect a pacemaker, such as hairdryers, table saws, car battery chargers, and electronic body-fat scales. Here are recommendations for persons with pacemakers, provided by HealthLinkBC[2]:

- Avoid devices with strong fields such as
  - MRI Machines
  - Certain welding equipment
  - Electronic body-fat scales
- Use Caution around other devices:
  - Keep pacemaker 60 cm (24 inches) from:

[1] Pots and pans used on an induction cooktop need to be ferromagnetic, which is a property of certain material such as iron, cobalt, and nickel. Being ferromagnetic basically means that they are materials with some magnetization and that they are attracted to other magnets.

[2] https://www.healthlinkbc.ca/health-topics/pacemaker-living-well-it

        - Jumper cables
        - Table Saws
    - Keep pacemaker 30 cm (12 inches) from:
        - Car battery chargers
        - Ignition systems of gasoline-powered engines or tools
        - Induction cooktop stoves
        - CB radios
    - Keep pacemaker 15 cm (6 inches) from:
        - Hair dryers
        - Battery-powered and electric shavers
        - Vacuum cleaner motors
        - Electric powered tools such as a drill or lawnmower
        - Electronic devices that use wireless technology

Q: What are the effects of EMFs on diabetic devices?

A: Fewer guidelines are available to be found for insulin pumps. Some indicate that the field of an induction cooktop would not affect the insulin pump operation. Others warn to keep the pump 30-60 cm (12-24 inches) from such devices. The National Library of Medicine[3] of the US Government indicates that neither an insulin pump nor the transmitter of a continuous glucose monitor should be held directly over an active hotplate, but that a distance of 10 to 20 cm is sufficient to prevent interference with medical devices; although it also says that a distance of 50 cm is safer. A 2014 research paper found that having a cell phone next to your blood glucose monitor when taking measurements effected the accuracy of the results. These researchers recommended using the phones at least 50 cm away from home blood glucose monitors, although they did not give a basis for that distance.[4]

Q: Does it matter if the device is implanted? For example, an insulin pump that is not implanted.

A: No, it doesn't matter if a device is implanted or not. Depending on the design of the medical device, if there are strong EMFs near the device, there is a potential for interference. The main concern with implanted devices, and why they were the main type of device discussed in the presentation, is that they cannot be removed, so if a person has to go into an area with a strong EMF field, the device also goes into the field. For example, a pacemaker cannot be removed prior to a person undergoing an MRI, but an insulin pump that is not implanted could be removed for the short timeframe of the test to ensure that it is not affected.

Q: Do EMFs have an additive quality or overlapping fields do not increase the risk?

A: EMFs do have an additive quality, similar to that of light. For example, an object held within the light field of candle will have a certain level of illumination, and if a second candle is added nearby, the illumination on the object will be increased. When considering this addition of fields, it is important to remember that EMF fields decrease very quickly with distance, following the inverse square law. If you double the distance from the EMF field source, the field strength goes down by a factor of four. If you

[3] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10210111/
[4] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4258867/

triple the distance, the strength goes down by a factor of 9. So, when different EMF sources are present but are far apart, the field being added from the distant source is usually extremely small.

Q: I often get questions from the general public regarding EMF. Any suggestions on how RP professionals can approach these questions or any resources we can provide them?

A: The ICNIRP is an international not-for-profit organization that follows research into the health effects of non-ionizing radiation (https://www.icnirp.org/). They use this information to form guidance for people, industry, and research organizations with respect to the non-ionizing portion of the electromagnetic spectrum. On their website you can find information about the different frequencies of the non-ionizing EMF spectrum, their possible health effects, and recommended levels under which these fields should be kept. Their page on low-frequency EMF can be found here: https://www.icnirp.org/en/applications/power-lines/index.html.

The US governmental organization NIEHS (National Institute of Environmental Health Sciences) also has an educational booklet aimed at members of the public titled: "EMF: Electric and Magnetic Fields Associated with the Use of Electric Power" that is in a Q&A format and very accessible. The booklet can be accessed here: https://www.niehs.nih.gov/health/materials/electric_and_magnetic_fields_associated_with_the_use_of_electric_power_questions_and_answers_english_508.pdf.

Another well-respected source of information on ionizing and non-ionizing radiation protection is the Health Physics Society. They have a staff of health physicists who regularly answer questions from the public. By doing a search on "cell phone base station" on their website, a number of answered questions from the public can be found, including the following:
http://hps.org/publicinformation/ate/q11223.html
http://hps.org/publicinformation/ate/q13181.html
http://hps.org/publicinformation/ate/faqs/cellphoneqa.html
They also have a section dedicated to the topic: http://hps.org/publicinformation/ate/cat63.html

CAREX Canada is a group of research scientists with interest in occupational exposures to carcinogens. Their profile on radiofrequency can be found here: https://www.carexcanada.ca/profile/radiofrequency_radiation/

We also have a number of fact sheets on our website that can be used to assist: https://radiationsafety.ca/resources/factsheets/

Q: Do humans have any natural protection against the impact of EMF?

A: Research of non-ionizing EMF such as those from wi-fi, cell phones, and electric motors does show they can cause health effects under certain conditions. Low frequency or radiofrequency EMF can heat tissues. Strong magnetic fields may cause feelings of nausea or cause visual symptoms. The field strengths needed to have any of these effects occur would not typically be found within a home or residential neighborhood. Our bodies do not have any known mechanisms to stop these effects.

Q: Do you have any info on pregnancy impacts of EMFs?
A: The Health Physics Society is "a scientific organization of professionals who specialize in radiation safety."[5] They have a section of their website where people are able to ask radiation protection experts and receive responses. Please see the following for information about EMF:
http://hps.org/publicinformation/ate/q6609.html
http://hps.org/publicinformation/ate/q6568.html

Here are resources from the site with respect to both non-ionizing radiation such as EMF and ionizing radiation from sources such as x-ray and nuclear:
http://hps.org/publicinformation/ate/cat4.html
http://hps.org/publicinformation/ate/faqs/pregnancyandradiationexposure.html

Q: Can you share more information about generalized safe work precautions for an individual working with an implanted device?
A: There are a few things to consider when a worker has an implanted device. The first would be what type of EMFs could potentially impact the device and in what way. This information is normally obtained from the medical device provider. The second is what types of exposures to those types of EMFs might be encountered in the workplace, and where. Radiation surveys can be done to determine location and strength of EMF fields, if the information is not readily available. The third is what types of controls need to be put in place to prevent exposures which would cause undue harm.

It is not best practice to leave sole responsibility for prevention to that individual worker. The employer has responsibilities under Health and Safety laws regarding provision of a safe workplace as well as training employees on the hazards in the workplace. As such, employers should be involved in the determination of the risks of EMF to employees with implanted medical devices and the resulting required safety controls. If the source of the fields cannot be removed or shielded, then barriers, warning signs, training, administrative controls, etc., should be implemented.

Q: Do you have any recommendations for safely delivering radiotherapy to patients who have implanted medical devices?
A: This webinar was focussed on the effects of Electromagnetic Fields (EMFs), and as such, radiotherapy is outside the scope of the webinar. A very short answer is provided, but an in-depth answer is out of scope.

An implanted electronic device is an object that is placed inside a person's body and helps maintain the person's health. Examples of such devices include pacemakers and implantable defibrillators, hepatic pumps and pain pumps, and neurostimulators.

Depending on the type of device and its complexity, it is possible that during radiotherapy treatment of a patient, the radiation dose received by their device could either interfere with the function of the device or damage the device. Medical devices vary widely, and the only general precaution that can really be said is that proper planning with the oncology department is required prior to treatment of a

[5] http://hps.org/aboutthesociety/

person with such an implanted device. Generally speaking, treatment planning should be performed in order to decrease dose to the devices, considering entry, exit, and scatter doses.

Q: Has there been updates to safety regulations for EMF exposure? Based on studies pre 2012 from ICNIRP/IEEE and ACGIH a safe threshold was set at 1000 microtesla (10,000 milligauss).

A: As explained in the webinar, there are no regulations in Canada for power frequency EMF exposure beyond general duty to protect workers in Occupational Health and Safety Acts for provinces and territories. Health Canada's Safety Code 6 for radiofrequency EMF was last updated in 2015. It only has legal standing in Canadian workplace jurisdictions which adopt it into regulation, although workplaces could choose to adopt it as a best practice to meet a general duty clause.

Certain jurisdictions such as the City of Toronto have adopted a policy of "prudent avoidance" or "precautionary principle" to encourage limiting exposure to power frequency magnetic fields due to the association with childhood leukemia. This City of Toronto policy was adopted in 2008 and applies to public spaces and developments near transmission facilities where elevated magnetic fields can be anticipated and recommends keeping magnetic field exposure for children younger than twelve under 0.3-0.4 microtesla (3-4 milligauss) when practical and feasible at no-to-low cost. New and upgraded transmission lines are also assessed for health impacts and an EMF management plan is requested. A similar policy was implemented in 2007 regarding the siting of telecommunication towers and antennas. This policy aims to keep radiofrequency EMF to less than 100 times lower than the requirements of Safety Code 6 to prevent known health effects of RF EMF exposure (tissue heating and peripheral nerve stimulation) as well as possible health effects of RF EMF exposure (certain types of cancers, sleep impacts, non-specific symptoms).

Looking to international standards and guidelines which could possibly be used to inform best practice, the ICNIRP updated its RF EMF guidelines in 2020 and low frequency in 2010. The IEEE reaffirmed their LF EMF standard in 2007 and published an amendment to their 2005 RF EMF standard in 2010. The ACGIH also has recommendations for low frequency and radiofrequency, but the date of their last update is not readily available.