Cardiac Resynchronization Therapy (CRT)
What Every Patient Needs to Know

Cardiac Health System
April 2016
This booklet is prepared as a reference guide for you and your family. It contains information about how CRT functions, the surgical procedure procedure and follow-up care.

*Please bring this booklet with you when you come to the Cardiac Device Clinic.*

**DISCLAIMER**

The information provided in this guide is for information purposes only. It is not intended nor implied to be considered, or used as a substitute, for professional health care advice, medical diagnoses or treatment. It is meant to be a general guide to your cardiac procedure at Trillium Health Centre.

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THE HEART & ITS RHYTHMS

Normal heart rhythms start in the upper chambers of your heart (atrium) and are carried through cells to the lower chambers, known as ventricles. This allows the heart to contract and pump blood that carries oxygen and vital nutrients to the rest of the body.

When the heart's electrical signals travel from the atria to the ventricles, they do so through specialized conducting tissues: the Atrio-Ventricular Node (AVN), the Bundle of His, and the Bundle Branches - the Left Bundle and the Right Bundle.

The Bundle Branches

When there is loss of conduction at the level of the AV node, the result is a complete loss muscle contraction. This can lead to intermittent dizziness, fainting or even death. Permanent Pacemakers are used to treat this issue. When there is loss of conduction in the Bundle Branches, however, the effects on the heart muscle are less dramatic, but every bit as important.
Bundle Branch Block

Each of the two main Bundle Branches - the Left and the Right - can lose conduction ability. This usually occurs due to age-related degeneration or disease of the heart muscle in the area of the Bundle Branch. Thus, Right Bundle Branch Block or Left Bundle Branch Block can develop silently and be detected by change on a routine ECG, or very abruptly such as in an acute myocardial infarction.

The Left Bundle Branch is the larger of the two and is responsible for a larger portion of the muscular activation in the ventricles, especially in the Left Ventricle, which is the lower chamber responsible for circulating oxygenated/fresh blood throughout the body.

Left Bundle Branch Block

Because the Left Bundle Branch is the larger of the two and activates more of the heart, its loss of function is much more serious with respect to the heart's efficiency and co-ordination.

Optical timing map of Normal electrical activity (left) and Left Bundle Branch Block (right). Note how the Bundle Branch Block activation is fragmented and disjointed.
Consequences of Left Bundle Branch Block

Even in a patient with normal heart function, the presence of Left Bundle Branch Block predicts a greater need for Permanent Pacemaker over time and is associated with a trend to higher mortality.

Not surprisingly, then, in patients with heart muscle weakness, the effects of Left Bundle Branch Block are magnified, leading to a higher risk of:

- Congestive Heart Failure
- Hospitalization
- Further decline in heart strength
- Premature death

Intraventricular Conduction Delay (IVCD).

This is a form of conduction disease which is not quite as severe as Left Bundle Branch Block yet still results in delayed, inefficient contraction of the Left Ventricle.

Note how in IVCD the complex is widened, but not as wide as in LBBB.

Patients with IVCD may still benefit from CRT, however, the magnitude of response may be less, as the conduction disease was less severe in the first place.

A careful analysis of each patient's conduction abnormality on the surface ECG by the consultant Electrophysiologist will distinguish between these two conditions and identify patients within each category who may benefit more from CRT.
Resynchronization - CRT - may be provided by a low-voltage *Pacemaker* platform or a high-voltage *Cardioverter-Defibrillator* (ICD) platform.

Examples of CRT pacemaker and CRT Cardioverter. Note the size difference of each of the platforms.

Each platform will provide resynchronization therapy, however, if the heart muscle is especially weakened or damaged, the additional features of a Cardioverter-Defibrillator may be recommended.

The two platforms share key features, such as timing circuits, pacing output directions, energy levels and programmability. The ICD has a different battery composition and the ability to store energy in a Capacitor, which makes the device itself much larger, yet not last as long as a Pacemaker.
The Leads

The leads are flexible, insulated wires connected to the ICD. Depending on your needs, your doctor will decide whether you need one lead or a system of multiple leads. The leads are used to deliver the electrical impulses from the ICD to your heart.

The leads are inserted through a large vein in your upper chest that goes into the right side of your heart.

The key difference to a Biventricular System is, that in addition to the standard leads of a pacemaker or ICD - which are placed inside the major chambers of the heart (the Right Atrium and the Right Ventricle) - an extra wire, termed the "Left Ventricular Lead" is placed in order to pace the weakened or at-risk Left Ventricle. To avoid placing this lead into the fresh blood pool of the Left Ventricle, where clot formation is a concern, the lead is placed into a series of
small veins which travel behind and outside the Left Ventricle, thereby pacing it from the venous system.

These small veins drain into a larger vein called the *Coronary Sinus*, which in turn drains into the Right Atrium. Thus, by engaging the Right Atrium as is done in a standard pacemaker or ICD, a system of flexible wires and tubes can be used to place the lead into position to pace the weakened Left Ventricle beyond the Left Bundle Branch Block, re-establishing the best activation and contraction of the Left Ventricle.
Lead Placement

Proper placement of the Cardiac Resynchronization - or Left Ventricular - lead is critical when it comes to improving symptoms and heart structure.

This is entirely dependent on the structure of the patient's heart and most importantly the way their coronary sinus and branches are structured. Unlike the coronary arteries, which are visualized during coronary angiography for coronary heart disease, the coronary sinus and vein branches are different in every patient. In rare cases, the vein branches are practically non-existent. This is only seen during the case, when a venogram is performed to see the coronary sinus and veins.

A basal Posterior/Posterolateral position provides the best Resynchronization pacing location.
Lead Placement cont’d

Chest X-rays showing CRT system, with Left Ventricular Lead well-placed in Posterolateral Branch

Correctly placing the new Left Ventricular/Resynchronization lead depends not only on there being a vein branch in the best area, but also that the branch is large enough to accommodate the lead, both in width and length. The muscle which runs under that vein branch must be healthy enough to pace it - a scarred area is of no use. Finally, there must not be any stimulation of the *Phrenic Nerve*, which runs in close vicinity to the heart on the way to the diaphragm.

**Diaphragmatic Stimulation**

Although testing for diaphragmatic stimulation is performed during the implant, this only tests while the patient is supine/lying down. Once the patient, stands and walks post-operatively, subtle shifts in the heart’s position in the chest may bring it closer to the *Phrenic* nerve, resulting in Diaphragmatic Stimulation.

This usually feels like a "twitch" or "hiccup". Although it is unpleasant it is not dangerous. Reprogramming the Pacemaker/ICD settings in the Cardiac Device Clinic will do away with the phenomenon.
Cardiac Device Clinic

This is where all of our Cardiac Devices - Pacemakers, ICDs, CRT platforms - are cared for over the months and years post-implant. Undoubtedly, the first 3 months are the most active time, as the leads mature in place and the incision heals.

Cardiac Device Technologists assess each device based on its unique capacities taking into account the patient's specific circumstances. In a stable patient with longstanding device, this may take 20 minutes; more complex issues will take longer.

The attending Electrophysiologist is available at all times to consult on Cardiac Device patients if the Technologist identifies an issue which requires even more detailed consideration.

A) EKG of Left Bundle Branch Block

B) EKG of pacing predominantly the Right Ventricle. Note the wide, deep activation pattern

C) EKG of proper Biventricular Pacing. Note how the heart's activation is narrow and discrete.

Cardiac Device Technologists optimize the programming of each CRT device for most efficient function.
Response to Resynchronization Therapy

Resynchronization begins immediately after the new CRT system is installed. This has been seen experimentally in high levels of cardiac output, myocardial oxygen consumption, and blood pressure. The full effect on patient symptoms can be seen just as quickly, but because the improve cardiac activation actually *remodels* the heart to superior strength over the next 3-6 months, the full benefit may be seen to gradually amass over that time.

Regardless, as compared to living with Left Bundle Branch Block in Congestive Heart Failure, or chronic Right-Ventricular-Only pacing, Resynchronization has been shown to improve cardiac structure on Cardiac Ultrasound, plus provide important mortality benefits to all patients.

This graph shows how much CRT therapy not only improves symptoms (as reflected by one full improvement in Heart Failure Class from 3 to 2) but exercise capacity (longer 6-min walk) and ultimately the heart’s structure itself, with improved Ejection Fraction (LVEF).
**THERAPIES/TREATMENTS DELIVERED BY AN ICD**

Most (but not all) Resynchronization Therapy occurs with a basic ICD as the underlying system. ICD function, therefore, are worth mentioning.

**THERAPIES TO TREAT FAST RHYTHMS**

*Anti-tachycardia Pacing (ATP)*

This therapy is often used as the first means to try to correct your heart’s fast rhythm. For just a few beats, the ICD paces your heart faster than the abnormal rhythm it is experiencing. This pacing can take control of the heart’s rhythm and “break” the cycle of fast beats, allowing your heart to return to normal. ATP uses small impulses that are not usually felt by you.

*Cardioversion*

This therapy provides a single, low-energy shock to suddenly interrupt your fast ventricular rhythm and return you to your previous normal rhythm. This “shock” is a set amount of energy and therefore you may or may not be aware of it at the time it is delivered.

*Defibrillation*

This therapy provides a single, high-energy shock to disrupt a life-threatening rhythm such as ventricular fibrillation. Because it is a high-energy shock, this therapy may be painful or uncomfortable. However, the discomfort lasts a fraction of a second and does not cause lingering pain or damage. You may feel a kick or thump in the chest, a light flutter or palpitation, or nothing at all.
If you happen to pass out from a life-threatening rhythm, you will not feel the shock. If someone is touching you while you receive ICD therapy, they may feel a small thump similar to a muscle twitch but will not be harmed.

**THERAPIES TO TREAT SLOW RHYTHMS**

**Pacing**

This function of the ICD monitors the heart’s electrical activity and responds when your own heart rate is too low. The electrical impulse that is sent from the ICD is strong enough to stimulate the heart to beat but not strong enough for you to feel. The ICD only paces when the heart needs it.

**YOUR THERAPY**

Every patient’s therapy needs will be different and they may change over time. The heart doctor will make the decision on what kind of therapy is right for you.

Remember that your medications are also an important part of your overall treatment and must be taken as directed.
PREPARING FOR YOUR CRT PROCEDURE

These are general guidelines for you to follow before you have your device implanted or replaced. Be sure to follow any specific instructions from your doctor and the Cardiac Device Clinic.

- Be sure you notify the Cardiac Device Clinic if you have any allergies to any medications (e.g. penicillin) or if you are on blood thinning medications (Warfarin, ASA, Plavix, Aggrenox, Ticlid).

- Arrangements will be made for you to have pre-operative tests, usually done one to four weeks before your expected procedure. These typically include:
  - bloodwork
  - urine test
  - ECG
  - chest x-ray

- Shower or bathe the evening before or the morning of the surgery.

- **DO NOT** eat or drink anything after midnight the day before your surgery (this includes gum, candy and water).
• You will be given specific instruction if you are to have any medications prior to your implant/replacement. If instructed to take medications: take with a very small sip of water.

• CRT surgery is often done on an outpatient basis. This means that you will come to the hospital the morning of your surgery and go home later that same day. Please make arrangement for someone to bring you to the hospital and pick you up.

• If you have other health problems that may complicate your surgery, the doctor might decide to admit you to the hospital.

• You will receive a phone call one day prior to your surgery to confirm the final details. You will be informed of the time and location for check in.

• When you arrive to Day Surgery the nurses will prepare you for your ICD implant by putting an IV in your arm and assisting you with your gown.
**DURING YOUR CRT PROCEDURE**

You will be brought to the Electrophysiology Suite. Once there, the EP Suite Staff will put equipment on you such as:

- heart rate monitor,
- oxygen prongs/mask,
- finger probe to measure your oxygen levels and
- external defibrillation/pacing pads on you.

- Just before the procedure, you will be given IV medication to make you feel relaxed as well as antibiotics to prevent infection.

- Both your arms will be secured at your side.

- You will be required to lie very still and not move during the procedure.

- Sterile drapes will be applied. The only area that will be exposed is the area that your CRT will be implanted which is usually just below the collar-bone.
• The implanting doctor will let you know before the area below your shoulder bone is “frozen”. You will feel a pinprick and a slight stinging sensation. Sedation will be given for comfort; most patients doze.

• Generally, a small incision 2 – 4 inches long is made below your shoulder bone.

• The leads are advanced through a vein until they are inside the heart. During the surgery, x-rays are used to help find the correct location for your leads.

• Once the leads are in place, electrical testing will be done to ensure that they are doing their job appropriately. Sometimes, the leads may need to be moved to ensure a good location.

• A further test, called DFT, may be performed once the leads have been connected to the device to ensure its correct function. The doctor will give you medications through the IV to put you to sleep for a short time while this testing is conducted.
RECOVERING AFTER YOUR CRT PROCEDURE

You will be transferred to the Recovery Room where you will be monitored for 1 to 2 hours. If you are an inpatient at Trillium Health Centre, you will be transferred back to your bed.

If you are an outpatient, or if you came from another hospital where you were an inpatient (e.g. Credit Valley Hospital), you will be taken to the Cardiac Short Stay Unit.

The health care team will arrange for your chest x-ray and ECG. A member of the Device team will come and check both the chest x-ray and ECG, prior to you being discharged.

Because you will have received medication that may make you drowsy, you must have someone drive you home and be with you for 24 hours. **You will not be allowed to drive yourself home.** Please make the necessary arrangements in advance.
Possible Signs Of An Emergency
Go to the nearest Emergency Department or call 911 if you experience the following:

- **shortness of breath** or increased shortness of breath after the implant
- experience **hiccup**s that last more than 1 to 2 hours
- **extreme swelling** of the arm or wrist on the same side of the ICD implant
- **oozing blood** from the bandage (do not remove and go to the nearest Emergency Department)

Taking Care of Your Incision

- You will have a bandage over your incision after your procedure.
- The incision will be closed by suture material that will dissolve on its own and does not need to be removed.
- Steristrips will be applied over the incision that helps keep the incision closed.
- Some discomfort, tenderness and bruising are common around your incision. This generally resolves over a few days to a week. You may take non-aspirin pain relievers containing acetaminophen (e.g. Tylenol) as needed for discomfort.
- The health care team will check & possible change your dressing the next morning.
- The outer dressing should be removed after day 3 of your procedure unless otherwise instructed by the health care team.
- The steristrips will loosen with time and are to be removed after 10 days.
• You may shower or bathe 4 days after your CRT implant. However, you should **not** direct the full force of the water on your incision area. Try not to get the steri-strips too wet. Water will not harm your CRT.

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**Daily Checking of your Incision and CRT**

You MUST observe the incision and site of your ICD on a daily basis. If you notice signs of any of the following, **YOU MUST IMMEDIATELY** report it to Cardiac Device Clinic. If you are unsure, call us anyway.

- increased redness,
- swelling,
- localized pain,
- oozing from the incision or opening of the incision.

Do not touch, rub, or scratch at your incision or CRT area. You may cause the leads and/or CRT to move from where they are supposed to be!!
The Newly Implanted Lead(s)

The lead(s) that has been placed inside your heart will not be stable for approximately six weeks. Until it is known that the leads are secure within your heart, you will need to follow the specific instructions listed below:

Arm Limitations & Exercises

- All patients will be given a sling that should be worn until they return the following day to the Cardiac Device Clinic for their first visit. The sling is very important in order to restrict arm movement for 24 hours.

- Do not raise your arm above the level of your shoulder on the side of the incision until after your 6 week appointment in the Cardiac Device Clinic.

- For 6 weeks after your surgery, do not lift, push, pull anything over 5 pounds or use the affected arm in repetitive movements that could dislodge the lead(s) such as:
  - vacuuming, swimming, golfing, bowling, raking, shoveling

- If you have had a CRT replacement only, without new leads being implanted, there are generally no arm restrictions. Confirm this with the Cardiac Device Clinic.
1. 2 days after your surgery, you **must start using the arm** on the side where the CRT was placed. If not, you could end up with limited movement of your shoulder joint.

2. Hold your arm outstretched at your sides (no higher than your shoulder level) and make 8-10 small circles in the air 3 times a day for the first 6 weeks after your surgery.

**Resuming Activities**

- You and your doctor will decide when you may resume your regular activities, return to work and sexual activities. If you have been hospitalized for a period of time, try to increase your activity slowly.

- There are specific criteria that your doctor and the Ministry of Transportation must follow regarding your license to drive or not to drive. Talk with your doctor and the Cardiac Device team for your individual specific needs.
Identification Card
Following surgery, you will be given the model number, the serial number and the name of the company who manufactured your ICD. Your ICD is registered with the manufacturer and a laminated identification card will be mailed to you by the company. You should carry your ICD Identification card in your wallet at all times. If your demographic information changes, please notify the company immediately, so that records can be updated. The company telephone number will be on the card.

Medic Alert Identification
A Medic Alert bracelet/necklace identification should be worn at all times. If you fall unconscious, the Medic Alert identification will let people know that you have an ICD and also give information about other health problems you may have. After your ICD implant and before you leave the hospital, you should receive a Medic Alert application form. If you already have a Medic Alert, you must contact them in order to update your information.
FOLLOW-UP OF YOUR CRT
If you require an interpreter, please bring an English speaking family member or friend with you to all your appointments.

What to Bring to Each & Every Clinic Visit
• Ontario Health Card
• Device identification card (temporary or permanent)
• Medications: bring current medications in the original bottles (Please do NOT bring a list of your drugs)

After your CRT implant, you will have follow-up appointments with the Cardiac Device Clinic at the time intervals specified below:

• 1 day
• 6 weeks
• 3 months
• every 6 months unless there is a reason that the clinical staff wish to follow sooner.

Your follow-up appointment will include:

• I.D. card review,
• medication review,
• blood pressure,
• device follow-up/testing and
• a visit with the heart doctor.
The Cardiac Device Clinics are busy and there may be some waiting. It is suggested that you not plan other appointments around the same time as your follow-up appointment. We will appreciate your patience. Your next follow-up appointment will be scheduled for you before you leave the clinic.

Please note that this clinic is not meant to replace the general medical care of your family doctor and/or heart doctor in your community. A letter will be sent to your doctor after each clinic visit.
CARDIAC TESTS
A variety of tests may be performed on your heart to help determine how it is functioning and which treatment would best suit you. The following is only a brief description of a few common tests that may be performed. Other tests not listed in this book may also be performed and can be discussed with your doctor and the Cardiac Device Clinic.

ECG/EKG (electrocardiogram)
An ECG is a diagnostic test that measures and records your heart rhythm from the exterior or surface of your body. This test is designed to show how electrical signals travel throughout your heart. Your particular heart rhythm can be determined from the information gathered from an ECG.

ECHOCARDIOGRAM (echo)
An echo uses high-frequency sound waves (ultrasound) to produce a picture of your heart. It allows your doctor to see structures of your heart such as the walls of the heart, the heart valves and the large blood vessels. The flow of blood through the heart can be visualized.
GXT (graded exercise test)
This test continuously monitors your heart rate, heart rhythm and blood pressure while walking on a treadmill. If this test is done, the information gathered may be used to help program your ICD.

EPS (electrophysiology study)
An EPS consists of ECG readings recorded from the inside of the heart using catheters. Sometimes, rapid rhythms are started to check the abnormal rhythm and your heart rate. Also, the heart doctor wants to know how your medications and ICD reacts to the abnormal rhythm.

MUGA (multi-gated angiography)
or RNA (radio nuclide angiogram)
This test involves the intravenous injection of a substance that would allow an image of your heart to be produced. This test is often used to determine the strength of your heart’s pumping ability.
**WHAT TO DO IF YOU RECEIVE ICD THERAPY**

Stop what you are doing and ask yourself how you feel:

<table>
<thead>
<tr>
<th>Shocks</th>
<th>What to do</th>
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</thead>
<tbody>
<tr>
<td>If you received ONE shock and feel well</td>
<td>Call the Cardiac Device Clinic for further discussion</td>
</tr>
<tr>
<td>If you received TWO or more shocks and feel well</td>
<td>Call the Cardiac Device Clinic for further discussion (if after hours or weekend go to the closest Emergency department).</td>
</tr>
<tr>
<td>If you received one or more shocks and feel UNWELL</td>
<td>Go to the closest Emergency Department</td>
</tr>
</tbody>
</table>

**Remember:** if going to the hospital bring your ICD I.D. card and your medications with you.

**Remember:** write down the date, time, symptoms and activities surrounding your shock
FREQUENTLY ASKED QUESTIONS

Other Medical Procedures

If you require any type of surgery or treatment, you need to inform all your Health Care Providers that you have an ICD. Also inform the Cardiac Device Clinic, as your ICD may need to be reprogrammed as certain medical equipment may interfere with the ICD. If you are unsure about a treatment you need to undergo, don’t hesitate to call us to discuss your concerns.

Travel

Most often, your ICD will not prevent you from traveling to most countries in the world. Please discuss traveling with your Cardiac Device team before making any arrangements. Airport security systems contain metal detectors. Remember to show your ICD I.D. card to airport security. Usually, they prefer to check you manually or use the handheld wand. Plan to add an extra 5-10 minutes to your pre-boarding time to get through security.

Dental work

You should inform you dentist that you have an ICD.
**Cellular Phones**

Cell phones should be used on the opposite ear to the side where your ICD was implanted. Cell phone antennae should be kept at least 6 inches away from your ICD, therefore, do not place a cell phone in the breast pocket of your shirt or jacket on the same side as your ICD. If your ICD is in your abdomen, don’t clip the phone to your belt near the device.

**Electrical Appliances**

General household appliances are safe to use, provided they are properly grounded and are in good condition. Examples of appliances and other household objects that **will not** interfere with your device include: microwaves, cordless phones, TV/VCRs, AM/FM radios, computers, toasters, and hairdryers.

**Sexual Relations**

The ICD should not deliver therapy for the natural increase in heart rate that happens during sex. However, if this happens, your partner may feel a tingling. The shock will NOT hurt your partner.

**Electromagnetic Interference (EMI)**

Electromagnetic Interference refers to electrical signals (outside of the ICD) that may affect your ICD. Your ICD is sensitive to strong electrical and magnetic fields. The following will interfere with the proper functioning of your device
Medical Sources of Interference:
Prior to undergoing any the following procedures or coming in contact with any of the items listed below, you must tell your physician(s) that you have an ICD and/or call the Cardiac Device Clinic staff for information:

- Electrocautery
- Cardioversion
- Defibrillation
- Magnetic Resonance Imaging (MRI)
- Lithotripsy
- Tens
- Diathermy
- Radiation
- Dental procedures
- Ultrasound
- Electrolysis

Non-Medical Sources:

- Cellular phones
- Improperly maintained household appliances
- Jewelry containing (feel good) magnets
- Large stereo speakers and strong magnets
- Car engines
- Arc welding
- Chain saws
- Ham radios
- Anti-theft devices

Death and the ICD
The Health care team understands how difficult it is for a family to deal with the passing of a loved one. However, we kindly request that the implanted ICD be returned to us for examination. Please ask a member of your family to call us to arrange this. Also, please tell your doctor and family about this request so that the funeral home can be informed. However, if you have chosen to be cremated, the ICD must be removed; if you have chosen to be buried, the ICD can be buried with you.
MORE ABOUT YOUR ICD

- Your ICD and leads have been thoroughly tested during each step of the manufacturing process however, as with all devices, not all is 100% foolproof.

- If a problem should be noted on any of your specific hardware, you will be notified by the clinic of the issue and discuss management.

- ICDs do not prevent your rhythm problems instead they treat these problems if they arise.

- The ICD is designed so that you can carry on as much of a normal lifestyle as possible. The goal of ICD therapy is to allow you to lead a life that is as good as or better than you could before the ICD.

- The Heart and Stroke Foundation of Ontario recommends that family and friends of people with heart disease receive training in CPR. It is a good idea to swim with a buddy.
RESOURCES

ICD Company Telephone Numbers

Biotronik Canada Inc. (416) 620-0069
Boston Scientific (Guidant) 1-800-268-4487
Medtronic of Canada 1-800-268-5346
Sorin Group (ELA) (416) 751-8787
St. Jude Medical (905) 812-8600

Internet Addresses

The following is a list of websites you may be interested in viewing to obtain further health information. This is only a short list of the many resources that are available and you may wish to collect more. To assist you with this, we have included a space for you to note down additional web links.

www.hrspatients.org

Questions/Notes

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City: ___________________________ Postal Code: __________

Donation:
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□ I have enclosed a donation cheque

Please direct my donation to:
□ Cardiac Device Clinic
□ Cardiac Catheterization & Electrophysiology Laboratory
□ Trillium Health Centre Foundation area of greatest need

Please email, fax or mail this form along with your donation to:

Trillium Health Partners Foundation
Clinical & Administrative Building
Trillium Health Centre
100 Queensway W.
Mississauga L5B 1B8
T: 905.848.7575
F: 905.804.7927