Diffuse Electron Donation by Heliopatch versus Directed Electrical Flow

Electricity gets a scary reputation and one that is quite deserved. The memorable aspects of any technology are the dramatic ones with lethal outcomes. Chemistry and physics instructors know that the example that garners the most attention is the one that ends with a grisly outcome, so these are often highlighted.

It is much less common to talk about the thresholds of safety and defining where the lethality of a particular phenomenon ends. This is always difficult to know because a lethal dose for one person may be nothing to the next. Lethality or harm may depend upon many factors such as physical conditioning, preexisting conditions and genetic susceptibilities. Most tests for damage and lethality are done in animals, and it may be very hard to extrapolate to humans. This is especially true for electricity, where a larger body makes the current more diffuse. Talk about safety thresholds are avoided because oftentimes these examples are meant to scare people and prevent them from even considering experimentation. These "Tales of Safety" function in much the same way that Grimm fairy tales were intended to stop children from unauthorized exploration.

There are some indications of what makes electricity more or less hazardous that are already well understood. Among electronics technicians, for instance, a grounding strap is applied to the wrist on the dominant hand. If electricity flows through the tool, it has only a short distance in the body before it flows out of the hand at the wrist. Technicians will often use more than one tool in just this dominant hand in a "chopstick" style because if tools were in both hands and one were acting as a ground while the other was on the hot, then electricity would flow from the ungrounded hand, through the heart and to the ground strap on the other hand. This example is particularly important when we distinguish electrical flow from an electrical service to the ground, since this provides a distinct "in" and "out" for electricity with the tissues intervening between these two points subject to the greatest damage. An example of this is the positioning of a defibrillator on the chest of someone who has had a cardiac arrest. The paddles are placed on each side of the chest so that the current flows through the heart. If the cardiac arrest occurs during open chest surgery, the surgeon uses paddles that are applied to either side of the heart to achieve the defibrillation effect. If these paddles were placed ipsilateral (on the same side of the heart) without the heart in the middle, the effect would be minimal if there was any benefit at all.

Many of the negative effects of electricity are related to the use of alternating current versus direct current. Alternating current has a tendency to constrict muscles and paralyze the person in contact with the electrical source, while direct current has much more predictable effects and tends to cause the person to recoil and release the source of the power. Direct current is considered much safer than alternating current.

I have often heard the quote, "It isn't the volts that kill you, it's the amps." It turns out that this true only for an example like the static discharge you get when you touch your finger to a grounded object. There is an excellent video that illustrates this point quite well here: https://www.youtube.com/watch?v=8xONZcBJh5A

Knowing that voltage is related to the potential for harm from the equation V/R=I, some typical values for voltage that cause an annoying tingle are 30V and up to 50V where the shock becomes painful. Above this there is real danger, especially if the person touching the source has a pre-existing heart condition. Since heart attacks often happen without any particular stimuli, it is difficult to establish a cause and effect for electrical flow that directly stimulates the heart and causes a heart attack and the stimulation that causes pain and subsequently the pain causes a heart attack. This is confounded by coincidence- i.e. perhaps you were about to have a heart attack before you touched the electricity. In addition, after an electrical shock people often get checked out, and many of us walk around every day with enough blockage to be considered heart attack worthy, but who write off the pain of angina as heartburn; for these people, an electric shock may be the precipitating event that makes them see a medical professional and obtain proper diagnosis and treatment.

The example of the static charge built up on a person's body is a good one when we are contrasting the phenomenon of electron donation to the effect of electricity. In the case of a static charge, the amps may be as high as 8 amps and several thousand volts. This would be more than enough to kill, but the electrons are not flowing in a directed way. These electrons are coming from throughout the body where they are stored in a capacitative way. These electrons are diffusely spread and don't become concentrated until they flow out through the finger that is touching the grounded metal object. These electrons don't take any particular route to the finger, and the only place they are concentrated is in the fingertip. This makes the effect painful, but not lethal. Also consider that the amps drop dramatically upon discharge so there is no continuous insult. A static electric spark is once and done until the charge builds up again.

The flow of electrons in a Heliopatch is similar to the spark in that it is diffuse, but the diffusion of electrons is going the opposite direction- into the body rather than out of it. This diffuse nature of flow means that there is not channeling of electrons through the heart. If a Heliopatch is placed on an open wound or an exposed nerve ending, the electron flow is fairly concentrated at that spot and can cause some pain because of a direct flow that stimulates the exposed neuron. This stimulation of a peripheral neuron, while painful, is unlikely to kill or cause any lasting harm. Diffuse flow of electrons is axiomatically safer than the same flow of electrons from point A to point B with the heart in between.

The voltage possible from a Heliopatch is calculated to have a maximum of 4.75V when magnesium gives an electron to the hydroxyl radical. This voltage is below the usual perceptible range when placed on skin. The nine volt battery doesn't even give a perceptible experience unless it is applied to the tongue. Likewise, touching the two terminals of a 12V car battery with bare skin is also imperceptible. When we apply a volt meter to the magnesium and a human, the highest voltage we have measured is an initial 4V spike with 1.9V steady state voltage.

The amperage possible from a Heliopatch is limited by the free radicals in the body and the amount of resistance the flesh of the body provides as the distance increases. This means that when applied to the skin, there is a limit to the number of electrons (amps) that can flow based upon how many free radicals are in the area of effect and how large the area of effect is (the resistance of the body multiplied by the distance). The number of amps is also limited by the surface area of the magnesium in the patch and the oxidized corrosion layer that covers it. When we have measured amperage from a Heliopatch, we have seen that 50 microamps is the typical maximum amperage. This is well below the range considered dangerous. To compare, one milliamp is considered to be the perceptible level and below this to be imperceptible. One milliamp is 1000 microamps, so the highest amperage from a Heliopatch is $50/1000^{th}$ of the 1mA perceptible level. This translates to 0.05 or five hundredths of the 1mA level. This level of amperage has been used as an electrical stimulation on wounds to enhance healing, and this was often used on patients who were quite ill. The endogenous current in a wound is reported to be in the range of 70-90 microamps, so these are currents that are within the range of biological relevance. A great number of studies have been done at these levels of current and the following review by Yu et. al reveals that these have been used without incident. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4440595/

It is important to note that these microcurrent wound dressings are directed current with a positive and negative terminal in contact with the skin, and even with the directionality of flow established there is not damage to the tissues between the two electrodes.

Iontophoresis is another technology that uses much higher amperage and voltage than Heliopatch to drive ions into the body. These devices have been used with such safety and success that they are available over the counter and the only hazards noted have been from users who leave them on for extended periods of time contrary to the directions, causing erosion of the skin. A recent review of their medical device status by an FDA panel concluded that these devices were safe enough to lower their classification and open them up to broader use. http://www.fda.gov/downloads/AdvisoryCommittees/CommitteesMeetingMaterials/MedicalDevices/MedicalDevicesAdvisoryCommittee/OrthopaedicandRehabilitationDevicesPanel/UCM386449.pdf One application of iontophoresis actually puts two hands on the two electrodes, which would direct any current through the area of the heart, yet this tapwater iontophoresis for hyperhidrosis carries with it no warning about heart conditions, probably because there have been no reported incidents. This is directed flow through the area of the heart and at higher voltage and amperage than Heliopatch can possibly produce.

We can make many arguments about the safety of Heliopatch for those with heart conditions by pointing to other electrically active technologies with far greater potential for harm based upon the physics of the heart and what we know from our experience with many other devices. Ultimately, you have to make the decision yourself and for your patients about whether these arguments are convincing. While it is likely to be a while before we do controlled studies with human heart patients we hypothesize that there will be some effects- positive ones. We predict that if such studies were done we would see gradual improvement of heart function as a result of decreased oxidative stress.