Vanquishing Nature by Mechanizing the Heart

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Coronary Heart Disease (CHD) is the leading cause of mortality around the world (Marmot and Elliot, 2005). The heart, without a doubt, is what keeps us going every second. It is a muscular organ most concerned with the immediacy of mobilizing blood to oxygenate tissues, including itself. It is the advanced networks of coronary vascularization which can deliver oxygenated blood to the myocardium, allowing the heart to survive its burdensome role in the body. Once coronary arteries can no longer supply the myocardium; due to atherosclerotic narrowing; cardiovascular complications arise and beg for novel circulatory support.

Surgical intervention has often focused on fixing the arteries themselves, such as coronary angioplasty; where a small balloon is inflated inside a narrow artery to increase diameter; or stent implantation; where an expandable tube of mesh is inserted in the narrowed artery to help keep it open; and bypass graft surgery; where a blood vessel is removed from one part of the recipient's body and stitched into the coronary arteries to bypass those that are narrowed. If oxygen is the issue, why can't we mechanize the heart to the point that it doesn't require oxygen? A robotic heart perhaps? We'll get there.

If nature provided us with two hearts, similar to how it gave us two kidneys, would we ever have to worry about cardiovascular disease? We've taken this issue into our own hands and have went as far as developing a surgical procedure for giving someone two hearts, termed heterotopic heart transplantation (HHT) or piggy back transplantation. By stitching a donor's heart into the chambers of the recipient's heart, the host heart can be mechanically assisted in beating. Those receiving a second heart through HHT do so because the donor's heart would not be strong enough to quickly adapt to the recipient's high blood pressure (Maiti *et al*., 2016). The scarcity of available donated biological hearts calls for novel non-biological means of circulatory support, otherwise abiotic mechanization.

Such devices for mechanical circulatory support have already been approved by the Food and Drug Administration. Note that some of these machines require that the ventricles of patients are removed for implantation (Shemin, 2016). A benefit of these types of aids are that they're very advantageous for avoiding post-implantation rejection; however, turbulent bloodflow within these machines is thrombogenic (promotes blood clot formation) and can lead to ischemic strokes elsewhere in the body if the clot becomes an embolus (an unattached mass) (Shemin, 2016). As appealing as robotic hearts sound, we can't forget the dynamic nature of a biological heart and the fact that they depend on metabolic energy, not battery life. Changes in heart rate, contractility, duration of contraction, and heart size are all things not programmed into robotic hearts, potentially limiting their adaptability to situations like bouts of intense exercise. So, one may ask about the alternatives to having an entirely mechanized heart?

What if there was a jelly-fish like membrane that could be wrapped around the ventricles which, upon electrical stimulation via the heart's conduction system, compresses the ventricles to assist the myocardium in pumping? Maybe this device is a robust, yet flexible electroresponsive gel matrix innervated with conductive biomaterial fibers that tense up when exposed to a current, similar to muscle fibres. Biomimicry inspired contractile assistive devices aren't existent today, but how can we not fantasize about such possibilities. Nonetheless, cardiac patches do exist, but they have other mechanisms for action to aid heart tissue.

Cardiac patches are typically synthetic or natural scaffolds planted on the site of infarcted tissue, which carry with them undifferentiated progenitor cells, growth factors, and all sorts of bioactive molecules who's regulated diffusion promotes angiogenesis and myocardial regeneration at the infarcted site (Dengler and Radisic, 2007). Biodegradable patches will dissipate with time, and ideally leave behind new healthy tissue with more contractile potential than infarcted tissue.

Going back to the idea of jelly-fish inspired electroresponsive membranes: research efforts on the development of conducive patches (to better comply with the heart's mechanical work) has shown that their conductive properties have no detrimental effect on the heart's electrophysiology (Kapnisi *et al*., 2018). This is a recent and an amazing first step to reassure us on the safety of such materials. We can be confident that findings on cardiovascular bioengineering over the next decade will reveal remarkable strategies on how to treat cardiovascular disease and that we should welcome our imaginations to the diverse methods available on how to play with our heart's physiology, ultimately to extend life and improve its quality.

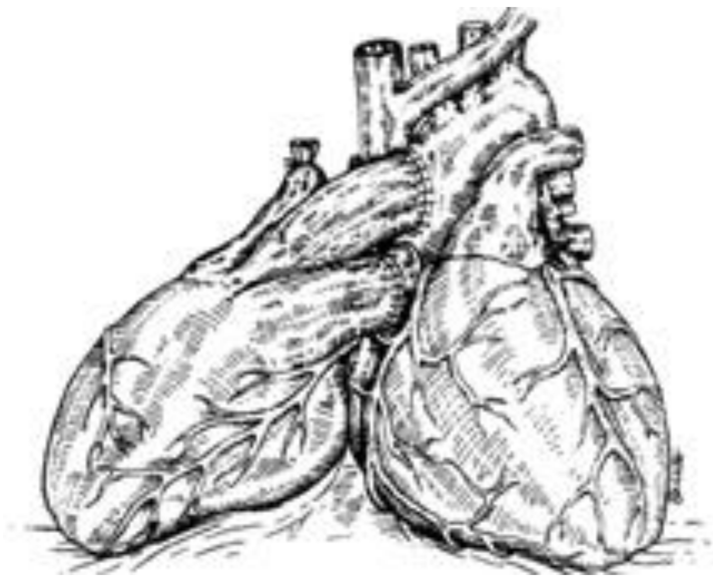

Fig 1. A sketch of a piggyback heart. Source[1]

Words: 760

[1]Sourcs: https://www.bbc.co.uk/blogs/today/tomfeilden/2009/07/the_rare_tale_of_the_piggyback.html

Citations

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