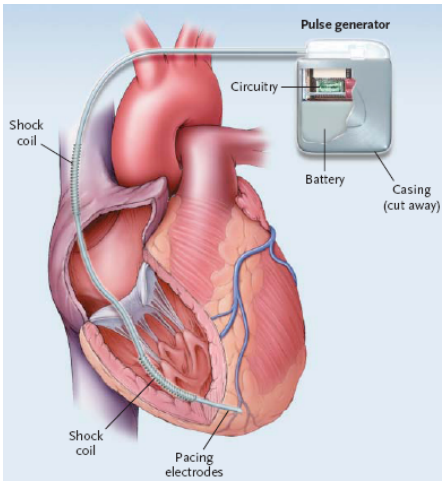
Implantable Cardioverter-Defibrillators

Daniel Reinhard – Biomedical Engineering – University of Rhode Island

Implantable cardioverter-defibrillators (ICDs) are implanted to immediately treat ventricular fibrillation, a fatal condition which occurs when the heart quivers rapidly and pumps little or no blood. Ventricular tachycardia is another condition where the heart will beat too fast and can be treated by an ICD. This device will sense the irregular beat and administer a lifesaving shock directly to the heart in order to restore a normal heart beat and prevent sudden cardiac death. These devices can also be programmed for bradycardia pacing, which means the ICD will sense a slow heart beat and send small impulses to help maintain a suitable heart rate. The first clinical implantation occurred in 1980, and now there a more than 160,000 ICDs being implanted annually in the United States alone.

Implantable cardioverter-defibrillators include a pulse generator, which is placed under the skin of the chest, near the collarbone. The pulse generator contains a header with ports for the leads, a battery, capacitors, memory chips, integrated circuits and microprocessors. There is also a transvenous lead that contains shock coils and pacing electrodes that connect to the right ventricle. Additional leads may also be connected to the right atrium and the left ventricle depending on the patient's specific condition.

Several clinical trials have been conducted involving the mortality rates for people with ICDs compared to conventional treatments. A collection of three secondary-prevention trials showed an average absolute reduction in mortality for patients with ICDs. Secondary prevention trials indicate patients that have previously experienced cardiac arrest due to either ventricular tachycardia or ventricular fibrillation. Another collection of four primary-prevention trials also showed an overall decrease in mortality for patients with an ICD. Primary prevention trials indicate patients that have been diagnosed with coronary disease, left ventricular dysfunction, inducible ventricular tachycardia, chronic coronary disease or patients with ICD therapy plus biventricular pacing. Follow up data on all of these studies lasted from about 1-5 years, with a 61 year old age average of the patient at the beginning of the study. It is difficult to compare the results of these particular studies due to the varying control groups and time constraints.



Some complications and problems with ICDs include: infection or erosion, connection problems, electromagnetic interference, frequent shock (appropriate or inappropriate) and psychological reactions. On average, ICDs cost $10,000-40,000 for the device and $6,000-12,000 for implantation. Expected battery life ranges from 4-9 years.

References:

- DiMarco, John P., "Implantable Cardioverter-Defibrillators." *The New England Journal of Medicine*. 349.19 (2003): 1836-1847.
- http://my.clevelandclinic.org/heart/services/tests/procedures/icd.aspx
- http://www.nhlbi.nih.gov/health/dci/Diseases/icd/icd_whatis.html
- Robert G. Hauser and Adrian K. Almquist, "Learning from Our Mistakes? Testing New ICD Technology." *The New England Journal of Medicine*. 359.24 (2008): 2517-2519.