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Defibrillation and cardioversion

Description

- **Defibrillation** - defibrillation refers to passing an electrical current across myocardium to depolarise the muscle, in order to convert a dysrhythmia back into normal sinus rhythm. It is the treatment for immediately life-threatening arrhythmias with which the patient does not have a pulse, ie ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT).[1]

- **Cardioversion** - is any process that aims to convert an arrhythmia back to sinus rhythm. Electrical cardioversion is used when the patient has a pulse but is either unstable, or chemical cardioversion has failed or is unlikely to be successful. These scenarios may be associated with chest pain, pulmonary oedema, syncope or hypotension. It is also used in less urgent cases - eg, atrial fibrillation (AF) - to try to revert the rhythm back to sinus.

The aim in both is to deliver electrical energy to the heart to stun the heart momentarily and thus allow a normal sinus rhythm to kick in via the heart's normal pacemaker, ie the sinoatrial node.

This article will discuss defibrillation and cardioversion. See also the separate Implantable Cardioverter Defibrillators article.

What is defibrillation?

At the end of the 18th century two physiologists, Prévost and Batelli, performed shock experiments on the hearts of dogs. They applied electrical shocks and discovered that small shocks put the dogs' hearts into VF and this was successfully reversed with a larger shock. It was first used in humans by Claude Beck, a cardiothoracic surgeon - on a boy aged 14 years who was undergoing cardiothoracic surgery for congenital heart disease. Electrodes were placed across the open heart. Closed chest defibrillation was not implemented until the 1950s in Russia. But it was not until 1959 that Bernard Lown designed the modern-day monophasic defibrillator. This is based on the charging of capacitors and then delivering of a shock by paddles over a few milliseconds. In the 1980s the biphasic waveform was discovered. This provided a shock at lower levels of energy which were just as efficacious as monophasic shocks.

Differences between monophasic and biphasic systems

- In monophasic systems, the current travels only in one direction - from one paddle to the other.
- In biphasic systems, the current travels towards the positive paddle and then reverses and goes back; this occurs several times.[2]
- Biphasic shocks deliver one cycle every 10 milliseconds and they are associated with fewer burns and less myocardial damage.
- With monophasic shocks, the rate of first shock success in cardiac arrests due to a shockable rhythm is only 60%, whereas with biphasic shocks, this increases to 90%.[2]
- However, this efficacy of biphasic defibrillators over monophasic defibrillators has not been consistently reported.[3] [4]

Types of defibrillators

- Automated external defibrillators (AEDs):[5]
    - These are useful, as their use does not require special medical training.
    - They are found in public places - eg, offices, airports, train stations, shopping centres.
    - They analyse the heart rhythm and then charge and deliver a shock if appropriate.
    - However, they cannot be overridden manually and can take 10-20 seconds to determine arrhythmias.
    - Unsurprisingly ease of use and speed of use are important factors for success.[6]
- Semi-automated AEDs:
    - These are similar to AEDs but can be overridden and usually have an ECG display.
    - They tend to be used by paramedics.
    - They also have the ability to pace.
- Standard defibrillators with monitor - may be monophasic or biphasic.
- Transvenous or implanted defibrillators.

Paddles versus adhesive patches

- Paddles were originally used but their use is being superseded by adhesive patches.
- Adhesive patches are placed most commonly antero-apically - the anterior patch goes under the right clavicle and the apical patch is placed at the apex.
- Adhesive electrodes are better, as they stick to the chest wall, so there is no mess with gels.
- Paddles require a significant level of force, which is not needed with adhesive electrodes.

- Adhesive electrodes also allow good ECG trace without interference.
- They are also safer, as no operator is required - although, before discharging a shock, it is important to ensure everyone is clear of the patient.

Energy levels for defibrillation [7]

For adults, a range of defibrillation energy levels has been recommended by manufacturers and previous guidelines, ranging from 120-360 J. In the absence of any clear evidence for the optimal initial and subsequent energy levels, any energy level within this range is acceptable for the initial shock, followed by a fixed or escalating strategy up to maximum output of the defibrillator.

The Biphasic Trial in 2007 compared lower fixed (150, 150, 150 J) and gradually increasing energy (200, 300, 360 J) shocks for out-of-hospital cardiac arrests.[8] Escalating energy shocks were associated with more frequent conversion and termination of VF as opposed to low-level fixed shocks. This applied to patients who remained in VF after the first shock.

The COACHED mnemonic is used to help safe defibrillation and stands for:

Continue chest compressions
Oxygen away
All else clear
Charging
Hands off
Evaluate the rhythm - shockable vs non-shockable
Defibrillate or Disarm

Paediatric defibrillation

- Shockable rhythms are pulseless ventricular tachycardia and ventricular fibrillation.
- Shockable rhythms are less common in children but may occur as a secondary event.
- It is seen more often in the intensive care unit and cardiac ward or in adolescents on the sporting field.
- Continue CPR until a defibrillator is available.

- Once the defibrillator is charged, pause the chest compressions, quickly ensure that all rescuers are clear of the patient and then deliver the shock. Minimise the delay between stopping chest compressions and delivery of the shock (<5 seconds).

- Give 1 shock of 4 J kg^{-1} if using a manual defibrillator. It seems reasonable not to use doses above those suggested for adults.

- If using an AED for a child of less than 8 years, preferably deliver a paediatric attenuated adult shock energy (50-75 J) if an attenuator is available. If one is not available use a standard AED which will deliver adult shock energy doses.

- If using an AED for a child over 8 years, use the adult shock energy.

- If using paddles, charging should be done with paddles on the chest, pausing compressions at that stage.

What is cardioversion?

Uses

- Decompensated rapid AF with a rapid ventricular response - eg, a hypotensive patient, not responding to medical therapy.[9]

- VT with a pulse.

- Supraventricular tachycardias including AF without decompensation; not acutely urgent.[10] [11]

In cardioversion the shock has to be properly timed, so that it does not occur during the vulnerable period, ie during the T wave. If this occurs then VT can be triggered.

Atrial fibrillation

- The success rate of cardioversion seems to be best (about 95%) at 12-48 hours after the onset of arrhythmic symptoms compared with a lower success rate of about 85% in later elective cardioversion.

- Early AF recurrences are also less common after acute cardioversion compared with later elective cardioversion.

- Cardioversion causes a temporary increase in the risk of thromboembolic complications. Effective anticoagulation reduces this risk, especially during the first two weeks after successful cardioversion. However, even during therapeutic anticoagulation, each elective cardioversion increases the risk of stroke -fold during the first month after the procedure, compared with acute cardioversion (within 48 hours) or avoiding cardioversion.

- Spontaneous cardioversions are common during the early hours of AF. The short wait-and-see approach, up to 24-48 hours, is therefore reasonable for otherwise healthy but mildly symptomatic patients who are using therapeutic anticoagulation, as they are most likely to have spontaneous rhythm conversion and have no need for active cardioversion.

See also the separate article on Atrial Fibrillation.

How to cardiovert

- Cardioversions are performed under general anaesthesia or sedation.
- Sedation decisions need to be made carefully.
- They are usually done in theatres with the support of an anaesthetist.
- The majority of cardioversions are elective procedures; however, some are performed when patients are acutely unwell with tachycardia - eg, chest pain, breathlessness.
- Decisions regarding sedation will need to be made and in practice this involves the anaesthetist.
- Turn on the machine and attach adhesive electrodes (efficacy may be better with anterior-posterior electrodes).[12]
- Choose the energy level.
- Get a clearly visible trace on the monitor - eg, using lead II.
- Hit the 'sync' button - usually a blip or dot appears on the monitor, marking each QRS complex.
- Higher starting energy is associated with better success and fewer shocks.[12]

- Broad complex tachycardia and AF: monophasic - begin with 200 J, or biphasic - 120-150 J.
- Atrial flutter and narrow complex tachycardia: monophasic - 100 J, or biphasic - 70-120 J.
- Charge.
- Ensure all is clear around the bed.
- Discharge or shock - there may be a 1- to 2-second delay as the machine ensures synchronisation
- Check rhythm after the shock - if sinus rhythm, then stop; if not, then you may need to deliver another shock at higher energy levels.
- Look for burns afterwards and obtain a 12-lead ECG.
- Sync may not be successful in tachycardias where the QRS complex has a variable morphology.

Further reading

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