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CARDIO-PULMONARY
Pacemakers in the Clinic

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Introduction/history

Implantation of cardiac pacemakers is a procedure widely used in human cardiology for the treatment of symptomatic arrhythmias. The first permanent cardiac pacemaker was implanted in humans in 1958, whereas in dogs the first permanent implantation took place in 1967 by Buchanan. Significant technological progress has taken place since, which has allowed the use of pacemakers of smaller size with multiprogram functions which offer a more physiological approach to the treatment of certain arrhythmias.

Indications

The following table presents the most common indications for implantation of pacemakers in canine patients:

<table>
<thead>
<tr>
<th>Tipo de arritmia</th>
<th>Incidencia (Johnson &amp; Martin 2007)</th>
<th>Incidencia (Wess et al. 2006)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bloqueo A-V 3º grado</td>
<td>65%</td>
<td>59%</td>
</tr>
<tr>
<td>Síndrome del seno enfermo</td>
<td>24%</td>
<td>27%</td>
</tr>
<tr>
<td>Bloqueo A-V 2º grado</td>
<td>4%</td>
<td>9%</td>
</tr>
<tr>
<td>Atrial Standstill</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sincope neurocardiogenico</td>
<td>7%</td>
<td>-</td>
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</tbody>
</table>

These arrhythmias tend to have higher prevalence in geriatric patients (except atrial standstill and neurocardiogenic syncope), and the main symptom is syncope, followed by lethargy, anorexia and exercise intolerance. Occasionally, these patients can develop congestive heart failure or cardiogenic shock. The incidence of such anomalies in the cardiac rhythm seem to be more prevalent in some breeds, although there is also certain geographic distribution. For instance, there is a clear higher incidence of 3rd degree A-V block in Labradors. Miniature Schnauzer seem to have a higher incidence of sick sinus syndrome, according to an american study (Wess et al 2006), although a british study (Johnson & Martin 2007) showed this condition as the most frequent in West Highland White Terriers.

Patient evaluation

It is important to observe a comprehensive diagnostic protocol in these patients because the main symptom is usually syncope (inspecific sign). Other common concomitant conditions will have to be ruled out in geriatric patients (i.e. renal failure, hyperadrenocorticism, etc). The following tests are recommended, although the diagnostic protocol will be specific for each patient, depending on the result of the clinical history and physical examination:
- Hematology
- Serum biochemistry (including specific biomarkers of muscular damage if an underlying muscular weakness is suspected)
- Troponin I: useful to diagnose myocarditis. In cases of high levels we can proceed with other tests to exclude certain infectious agents (i.e. Ehrlichia, Anaplasm, Bartonella, toxoplasmosis, FeLV-FIV, etc)
- Electrocardiography: including atropine response test
- Echocardiography
- Other type of electrocardiography recordings: 24 hours Holter monitoring, implantable monitors of continuous recording (Reveal Plus, Reveal DX)
- Hormonal tests: ACTH stimulation test, thyroid panel
- Orthopaedic and neurological examination
- Thoracic radiography
- Abdominal radiography/echography

**Equipment for implantation of pacemakers**

The equipment necessary for the transvenous implantation of permanent pacemakers consists of:

1. Material for implantation of temporary pacemakers
   a. Endocardial lead
   b. Pacing lead
   c. Temporary pacemaker
   d. Fluoroscope
2. Material for the implantation of permanent pacemakers
   a. Pulse generator
   b. Pacing lead
   c. Surgical kit
   d. Fluoroscope
   e. Programmer

The use of temporary pacemakers is recommended in patients with symptomatic bradydysrhythmias due to the high anaesthetic risk in these patients. However, this procedure is not always necessary and increases the time of the intervention. The temporary pacing lead is usually inserted through the saphenous vein in a sedated animal, aided by an endocardial lead (the author often applies 2% lidocaine cream as local anaesthetic 30 minutes prior to the placement of the endocardial lead using modified Seldinger technique) with the help of fluoroscopy. Once the electrode is advanced to the right ventricle, we can then control the cardiac rhythm externally with this temporary pacemaker (usually 70 bpm in VVI mode) and so proceed with the general anaesthesia of the patient.

**Permanent pacemaker**

The permanent pacemaker comprises a permanent electrode and pulse generator. The permanent electrode is usually introduced via the jugular vein by the “cut-down” technique and placed in the right ventricle guided by fluoroscopy. There are different types of permanent electrodes (unipolar/bipolar)
and two basic types of endocardic fixation: passive (atraumatic “hooks”) or active (with a small coil which is the ‘screwed’).

The pulse generator is a device made of titanium or stainless steel which can be programmed and has a battery (usually of lithium). The most frequently used are the bipolars pulse generators since they tend to have less interference with peripheral muscle. There is a five letter code to classify pulse generators:

<table>
<thead>
<tr>
<th>V</th>
<th>V</th>
<th>I</th>
<th>0</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cámara estimulada (V=ventrículo, A=atrio, D=cámara dual, S=cámara única, O=ninguna)</td>
<td>Cámara detectada (V=ventrículo, A=atrio, D=cámara dual, S=cámara única, O=ninguna)</td>
<td>Modo de respuesta (T = desencadenada, I = inhibida, D=doble, S=ninguna)</td>
<td>Programabilidad ad respuesta (P=programable, M=multiprogramable, C=comunicadora)</td>
<td>Funciones antiarrítmicas (P=pulso, M=shock, D=dual, S=ninguna)</td>
</tr>
</tbody>
</table>

These functions are programmable with the programmer or system analyser. We have to take into account the different programmers, depending on the manufacturer of the pulse generator, which are usually not interchangeable (i.e. Medtronic®, St Jude®). One of the most frequently used programs in canine patients programs is VVI00 (the stimulus takes place in the right ventricle, the impulses are sensed in the right ventricle and the pulse generator is inhibited if there is spontaneous pulse). Pulse generators are frequently programmed in VVIRO mode, in which case the heart rate will vary in response to the movement (i.e. the frequency of the pacemaker stimulating the right ventricle will increase if the patient is exercising).

The American College of Veterinary Internal Medicine, Cardiology department, offers pulse generators and pacing leads which can be obtained through CANPACER. In the United Kingdom, these units are usually donated by hospitals (units explanted from human patients or where the sterility expiry date is over, or inferior models) or by the manufacturers. These devices can only be re-sterilised with ethylene oxide.

**Technique for implantation of pacemakers (presentation)**

**Prognosis and evolution**

The patient tends to be kept hospitalised for approximately five days after the implantation of a permanent pacemaker. During this post-operative period, the surgical wound of the patient will be checked on a daily basis to identify seroma formation. Strict rest (often with a light sedation) and dressings of neck and body are often necessary. Prophylactic antibiotics are used to avoid infections. After this post-operative period, the patient is then discharged with instructions to rest at home for a minimum of two weeks, to then gradually reintroduce exercise for the following two weeks. It is recommended to use a body harness instead of a collar and lead, to avoid friction in the area of the pulse generator and endocardial lead. The use of prophylactic antibiotics (e.g. dental procedures) will be necessary to avoid the risk of implant infection. The pulse generator will have to be removed prior to incineration of the patient as it would explode.

4-weekly checkups are recommended after the implantation of a pacemaker. During the first checkup we will be able to measure pacing threshold parameters to calculate pulse amplitude and duration (degree and duration of the stimulus) which will then be used to program the pacemaker to ensure the safety of the pacing of the right ventricle with a minimal use of the batteries. These controls will then take place biannually during the life of the patient.
The published incidence of major complications is around 13% (Weiss et al 2006) and 14% (Johnson & Martin 2007), being the dislodgement of the endocardial leads the most common complication. The most common minor complication is the formation of seroma which usually resolves spontaneously. However, we have to take into account that these figures have been obtained from centres where the transvenous implantation of pacemakers is a relatively routine procedure (>1 pacemaker implantation/month) and hence, it has been performed by experienced surgeons (or by residents supervised by experienced surgeons).

<table>
<thead>
<tr>
<th>Probabilidad de supervivencia</th>
<th>Johnson &amp; Martin 2007</th>
<th>Weiss et al 2006</th>
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<tbody>
<tr>
<td>1 año</td>
<td>86%</td>
<td>85%</td>
</tr>
<tr>
<td>2 años</td>
<td>70%</td>
<td>-</td>
</tr>
<tr>
<td>3 años</td>
<td>55%</td>
<td>65%</td>
</tr>
<tr>
<td>5 años</td>
<td>-</td>
<td>39%</td>
</tr>
</tbody>
</table>

90% of the patients in the study carried out by Johnson & Martin showed resolution of the clinical signs.

**Summary**

The implantation of pacemakers is a technique that requires specialised training and equipment but represents the treatment of choice in cases of symptomatic bradycardias for which there is no effective medical therapy.

**Bibliography**


