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Vagal stimulation for treating syncope by cardioneuroablation without pacemaker implantation

The heart has a dense innervation that permanently regulates its activity. It is the autonomic nervous system, constituted by two antagonistic divisions, the parasympathetic and the sympathetic. The latter stimulates the heart, increasing cardiac rate and contraction force. Conversely, the parasympathetic portion, consisting of the right and left vagus nerves, permanently inhibits the heart causing cardiac rate reduction.

The denervated heart

When the heart is disconnected from the nerves the spontaneous cardiac rate increases due to the disruption of the vagus nerve inhibitory tonus (cardioinhibition). Therefore, one way to get heart rate increase is to provide the vagal denervation.

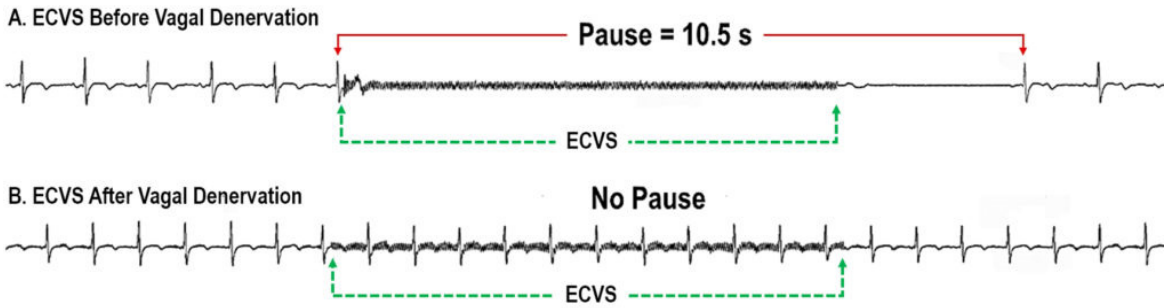

Fig. 1. A: Extracardiac vagal stimulation (ECVS) before cardioneuroablation (green line). It is observed an electrocardiogram in normal Rhythm. By starting the ECVS there is a complete asystole (cardiac arrest) that lasts more than the ECVS, causing a total pause of 10.5 seconds (red line). After the pause the normal cardiac rhythm is totally recovered.
B: A new ECVS is repeated after the vagal denervation. It is observed that there is no modification of the normal rhythm, with no bradycardia or pause. This response shows that the vagal innervation was completely abolished by ablation and the cardioneuroablation can be finished.

The problem of the vagal hyperactivity

Many patients suffer from symptoms such as dizziness or syncope due to vagal hyperactivity. In these cases, the vagal action becomes abnormally excessive causing slow heart rate or even pauses, AV-block or transient cardiac arrest. This occurs, for example, in the vasovagal syncope. Fainting from vagal reflex that causes cardiac arrest, or a very slow heart rate is known as “cardioinhibitory syncope”. It may be treated with a cardiac pacemaker implantation to prevent cardiac arrest.

Pacemaker: an undesirable solution

Many of these patients are young and, being the pacemaker a prosthesis, it is highly rejected. Furthermore, since the pacemaker does not prevent the vagal reflex, it has a low-resolution index.

Treating cardioinhibition without a pacemaker

In the 1990s we developed a new technique for treating cardioinhibitory syncope without pacemaker implantation named "Cardioneuroablation". This procedure consists of a venous puncture with introduction of a thin electrode into the atria for radiofrequency application at the vagal innervation entry. This causes a microcoagulation of the nerve endings eliminating the cardiac vagal action preventing the cardioinhibition (Fig. 1B). The cardioneuroablation allows most of these patients to be cured without a pacemaker implantation. It is painless, very well tolerated and needs only one-day hospital observation. The patient may return to his activities in three days.

Control and validation of cardioneuroablation

A successful cardioneuroablation depends on the confirmation that the radiofrequency is being applied at right points getting the denervation. Aiming this issue, we developed the Simplified Method for Vagal Effect Evaluation in Cardiac Ablation and Electrophysiological Procedures. This method allows to test the vagal denervation in real-time and determines the best endpoint to finish the cardioneuroablation (Fig. 1).

Extracardiac vagal stimulation

Vagal nerves leave the brain along with the jugular veins through the jugular foramen very close to the veins (Fig. 2C). Hence, during cardioneuroablation, we can easily advance one of the electrodes used in electrophysiological studies, going up the superior vena cava and internal jugular vein to the jugular foramen (Fig. 2B). At this point, through this electrode, there are applied electrical pulses stimulating the vagus nerve by remote electrical field. The result is an immediate asystole (cardiac arrest) that quickly recovers after the stimulus termination (Fig. 1A). This demonstrates the vagal innervation effect and integrity.

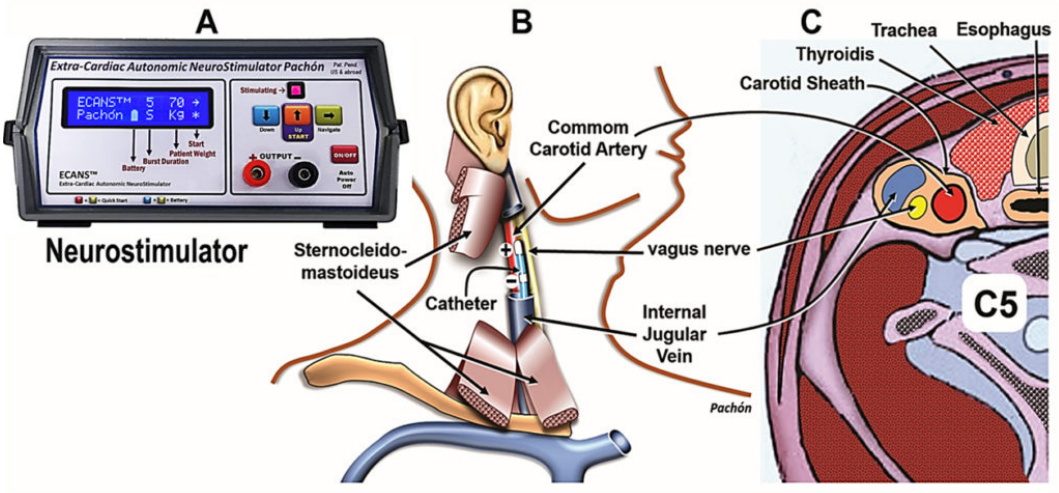

Fig. 2. A: Neurostimulator with specific features for making possible the vagal stimulation from inside of the internal jugular vein near the jugular foramen. The electrical properties are critically adjusted in order to get a remote efficient stimulation without any tissue lesion.
B: Scheme of the electrophysiology electrode inside of the internal jugular vein going to the jugular foramen area to accomplish the extracardiac vagal stimulation.
C: Scheme of a transverse section of the neck showing the close relation between the internal jugular vein and the vagus nerve.

Extracardiac vagal neurostimulator
The electrode inside the jugular veins does not have direct contact with the vagus nerve (Fig. 2B). Thus, it was necessary to construct a specific stimulator to release special pulses capable of stimulating the vagus from the vein inside, without direct contact. This device has a very strict control of frequency, amplitude, waveform and output impedance in order to assure full stimulation completely safe and with total absence of tissue injury (Fig. 2A).

Demonstrating cardioneuroablation success
At the cardioneuroablation beginning, a vagal stimulation is performed to confirm the intense vagal action characterized by induction of cardiac arrest (Fig. 1A). At the end of the cardioneuroablation, the vagal stimulation is repeated. In this case, the total absence of vagal action means that the procedure was successful, and that the cardioneuroablation can be finished (Fig. 1B).

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