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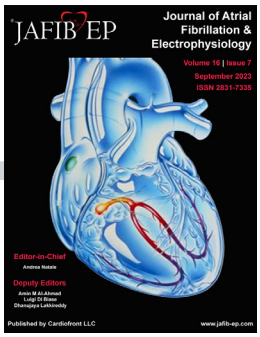

Cardioneuroablation as an Alternative Treatment Option for Patients with Carotid Sinus Syndrome

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Abstract

Background: Carotid sinus syndrome (CSS) is a condition caused by sudden autonomic nervous system imbalance with vagal overactivity. It may lead to sinus bradycardia, sinus arrest, and AV block with severe symptoms and syncope, which may be treated with a pacemaker (PM). Cardioneuroablation (CNA) is an atrial endocardial catheter radiofrequency (RF) ablation aiming vagal denervation that could be used to remove the cardioinhibitory response in the CSS as suggested in the original study.

Objective: To study the outcome of CNA controlled by extracardiac vagal stimulation (ECVS) in patients with CSS without significant cardiopathy.

Methods: Prospective, controlled study of eight patients with symptomatic CSS, positive carotid sinus massage (CSM), and normal atropine response. Bi-atrial RF-ablation of the neuro endo-myocardial interface was guided by filtered endocardial electrograms, fractionation, and 3D anatomical mapping, identifying AF-Nests (AFN) related to the four main ganglionic plexuses (GP) with bi-atrial RF ablation (irrigated catheter 30W/42°C/20-60s). ECVS (5s) at the left jugular foramen and CSM was performed before, during, and at the end of the ablation to guide the level of denervation, defining the higher CNA effect and end of the procedure, analyzing pauses and AVB, induced by ECVS and CSM.

Results: The mean age of patients was **58.6 (± 11.8).** Pre-CNA, CSM, and ECVS responses were asystole and transient AVB in all patients. Post-CNA, ECVS, and Atropine responses were completely abolished in seven out of eight patients. In a **31 ± 16.1** months follow up, one case with incomplete CNA experienced syncope recurrence due to AVB and was submitted to a new CNA for AVB becoming asymptomatic. Another case had a positive CSM six months after CNA and had a pacemaker (PM) implanted even though asymptomatic, as per his physician's discretion. There was immediate sustained HR **(58.9 ± 12,7/81,8 ± 4.9 bpm)** and Wenckebach's point increase **(133.5 ± 39.2 / 164.7 ± 10.8ppm), p: < 0,01.**

Conclusion: Complete bi-atrial CNA vagal denervation, based on AFN/GP ablation guided by vagal effect abolishment confirmed by ECVS and CSM responses, was effective in eliminating syncope recurrence in all patients with CSS.

Introduction

Neurocardiogenic syncope is the most frequent cause of reflex syncopes.[1] Autonomic dysfunction and transient or permanent vagal hyperactivity may have various clinical presentations: neurocardiogenic syncope (cardioinhibitory, vasodepressor, or mixed), sinus bradycardia, sinus pauses, transient functional atrioventricular block (AVB), sinus dysfunction and carotid sinus syndrome (CSS).[2] Management commonly involves the use of conventional maneuvers such as increased fluid and salt intake, elastic stockings, medications to prevent hypotension, and, in refractory cases, pacemaker implantation. In 2005, Pachon et al. proposed a novel alternative for the treatment of syncope with a significant cardioinhibitory component, based on predominantly vagal cardiac denervation through endocardial radiofrequency ablation, and named it Cardioneuroablation (CNA).[3] However, although

Key Words

Cardioneuroablation; carotid sinus syndrome; cardiac pacemaker; ganglionic plexuses; syncope

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CNA has been proposed as an alternative for the treatment of CSS, this indication was not included in the first study cohort due to the inclusion criteria of younger patients. Thus, this study aims to test the initial proposal of CNA in elderly patients without significant heart disease and repetitive syncopes caused by CSS.[4]

CSS is characterized by repetitive syncope triggered by an excessive response to carotid baroreceptor stimulation. Typically, these patients have an exaggerated response to carotid sinus massage and commonly reproduce spontaneous symptoms.[5,6] The incidence of CSS is estimated to be one percent of syncope cases,[7,8] and it is a common form of presentation in patients with advanced age and the presence of atherosclerotic disease. In these cases, the vagal response is commonly reproduced by carotid sinus massage, which induces cardiac inhibition (CI), with bradycardia, asystole, or AVB with a pause longer than three seconds, and/or a vasodepressor response with a 50mmHg drop in systolic blood pressure. In most cases, there is a mixed response with CI and vasodepression.[9]

In the search for alternative treatments aimed to suppress the carotid sinus baroreceptor vagal reflex, CNA emerges as a new option, aiming to eliminate CI through endocardial denervation, avoiding the need for pacemaker implantation.[10] Cardiac pacing, through pacemakers using Rate Drop Response (RDR) and Closed Loop Stimulation (CLS) resources, is the therapeutic option recommended in current guidelines, even in patients with structurally normal hearts and without myocardial dysfunction.[11] However, recent studies have shown that pacemakers do not stop the reflex and may not resolve all cases, with symptom recurrence rates up to 20% at a five-year follow-up.[5] Furthermore, they may also be associated with complications inherent to cardiac prosthesis implantation. Depending on the pacing site, pacemakers can be a cause of pacing-induced dysfunction, and is conditional on generator exchange procedures, infections, or problems in the pacing system, and is often unwanted by the patients.

In this study, we reviewed the applicability and safety of the use of the CNA in cases with repetitive syncope caused by CSS, refractory to conventional treatment, and with an indication for pacemaker implantation, according to current guidelines. This is a very specific and selective indication, since very elderly patients and those with associated heart disease were excluded from earlier CNA studies.

Currently applied in many centers worldwide, CNA has proven to be an appropriate option to prevent CI by reducing cardiac vagal innervation in cases of neurocardiogenic syncope in its various cardioinhibitory and mixed presentations, as well as in functional bradycardias, sinus node dysfunction, functional AVB, and atrial fibrillation. All these indications were tested in the initial study except for CSS.[3] Currently, there are numerous case series, observational studies, case-reports, and a randomized clinical trial comparing CNA to conventional clinical treatment. However, there is limited information regarding the usefulness of CNA in cases of CSS, which has been addressed in sporadic case reports and series.[12,13,14,15,16] Thus, it becomes relevant to evaluate the potential of this indication and the technique, as well as to analyze the results and the aspects of efficacy and safety in this specific group of patients.

In this study, we describe a series of CSS cases treated with CNA using objective methods to define the degree of vagal denervation and the proof of CI elimination by endocardial ablation.

Objective

The objective of this study is to investigate the efficiency, applicability, and safety of vagal denervation achieved by CNA for the treatment of CSS, controlled by extra cardiac vagal stimulation (ECVS) and carotid sinus massage (CSM), while also evaluating the clinical evolution and time to the presentation of new syncope events.

Secondary objectives

1. To evaluate, on an evolutionary basis, the response to carotid sinus massage after CNA.
2. To report possible complications related to the CNA procedure.
3. To analyze long-term adverse effects related to CNA and CSM including death, stroke, myocardial infarction, and pro arrhythmia.
4. To demonstrate the degree of denervation achieved by CNA and its efficacy for the control of syncope caused by carotid sinus hypersensitivity.

Methods

This is a clinical, prospective, controlled study including patients diagnosed with CSS, characterized by repetitive syncopes (>5 events in 12 months prior to recruitment) refractory to conventional maneuvers and treatment, and indication for pacemaker implantation, approved by the hospital's ethics committee. In addition to accurate clinical selection, patients underwent head up tilt test (HUTT), CSM, and atropine test **(Table 1)**.

Inclusion criteria

- Age > 18years.
- >5 syncope episodes in the last 12 months prior to recruitment.
- CSM with cardioinhibitory response and correlation with symptoms. Sinus pause and/or AVB > 5.0 sec.
- Positive response to atropine test, confirming the absence of significant sinus and AV node organic dysfunction.
- Indication for pacemaker implantation for CSS treatment.
- Patient consent after being informed of the risks and benefits related to the CNA procedure.

Exclusion criteria

- Presence of structural heart disease.
- Diagnosis of coronary artery disease by functional test, imaging, or history of prior myocardial infarction.

Table 1: Demographic and clinical data.

Age	44-80 (58 ± 10.2 years)
Sex	Female 3 / Male 5
LVEF %	64-72 (67.8% ± 2.5%).
Number of syncope episodes	7.6 (± 6.2)
Cardio inhibition reproduced in carotid sinus massage	8
Average pause duration	5.2 secs (±1,2)
Type of syncope mediated by vagal reflex	Type 2 B - 8 - 100%

– Diagnosis of intrinsic conduction system disease on electrophysiological study.
– Predominantly vasodepressor response induced by CSM.

Carotid sinus massage

After confirming the absence of severe carotid arterial disease by performing ultrasonography to rule out the presence of atheromatous plaques with stenosis > 50%, CSM was performed by compressing the carotid sinus for 3–5 seconds unilaterally in the inferior submaxillary region and over the site of palpation of the right and left carotid pulse.[6,17]

All included patients had a significant cardioinhibitory response, with induction of sinus pauses **(Figure 1)** or transient AVB resulting in asystole > 5 sec; **(Video 1 - baseline CSM pre-CNA).**

Atropine test protocol

The Atropine test was performed by intravenous infusion of 0.04 mg/Kg, with a maximum dose of 2 mg, of atropine sulfate, with electrocardiogram monitoring for 30 minutes. An increase in baseline heart rate to > 90 bpm within the first five minutes, and elimination of the vagal response induced by CSM was considered a positive response.[18,19]

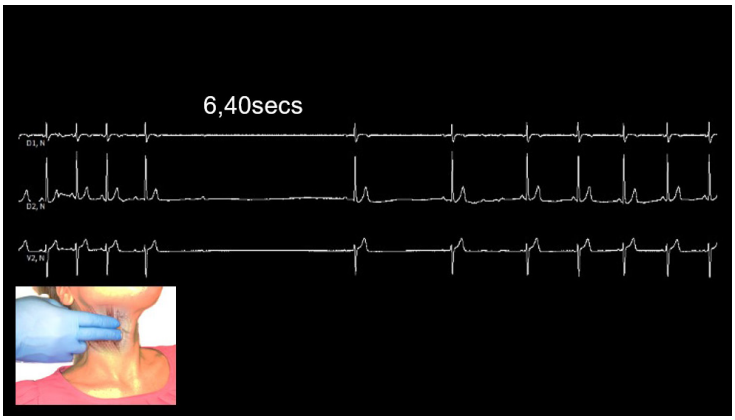
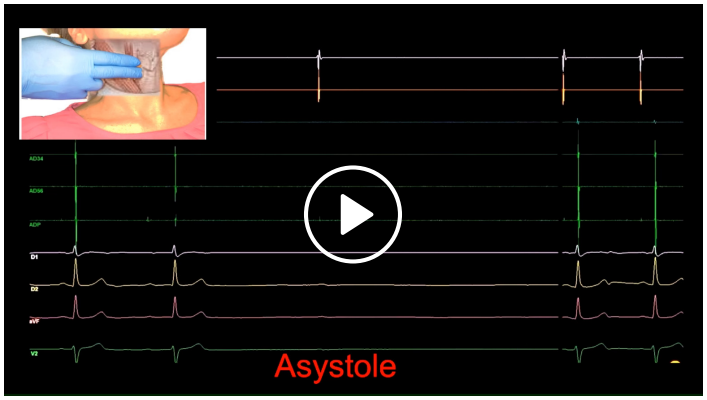


Figure 1: Cardio inhibition inducing sinus pause and asystole of 6.4 seconds in a patient with carotid sinus syndrome.



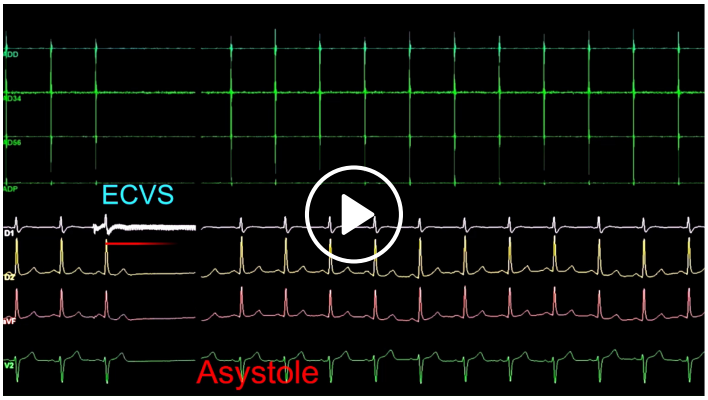
Video 1: Carotid sinus massage is performed inducing a significant sinus pause with periods of AV block.

Cardioneuroablation

CNA was considered after providing a comprehensive explanation of the risks and benefits to the patients, ruling out heart disease, and obtaining informed consent. The CNA procedures were performed under general anesthesia, with monitoring of brain activity by Aspect A-1000 BIS and cerebral oximetry measured by frontal infrared photoscopy spectrum, and monitoring of vital signs (heart rate, oximetry, blood pressure, plethysmography, peripheral perfusion, capnography, and respiratory gas pattern). Conventional electrophysiological leads were placed, and initial electrophysiological evaluation was performed analyzing sinus automaticity, atrioventricular conduction, Wenckebach cycle, and response to ECVS and CSM in baseline conditions, prior to ablation, confirming the absence of lesions of the electrical conduction system and the presence of sinus pauses and transient AVB induced through ECVS. Parasympatholytic drugs were avoided at this time.

The ECVS was performed according to the technique described by Pachon et al.,[20] using endovascular access through the femoral vein, a steerable quadripolar catheter was advanced to the jugular foramen near the cranial base in the right and left internal jugular veins. Stimulation was applied for 5 seconds with 50 µs/50 Hz/1volt/Kg of body weight up to a maximum of 70 V. In this stimulation, the vagus nerve is captured by an electric field, from the intrajugular electrode, without direct contact **(Video 2 - Pre-CNA basal vagal stimulation)**. The immediate effect is the induction of sinus arrest and/or high-grade AVB that typically reproduces the responses obtained with CSM.

CNA was performed with a bi-atrial approach. Trans septal access was guided through transesophageal echocardiography, followed by anti-coagulation through Heparin infusion (100 UI/Kg) to maintain the activated clotting time between 300–400 seconds. All patients were in sinus rhythm and underwent guided ablations by mapping the AF-Nests using the filter set to 300–500 Hz on the conventional recording system and by anatomical references of the ganglionic plexuses (GPs) on the electro-anatomical model.[3,21,22] Initially, an AF-Nest map was obtained during anatomy acquisition with the Ensite Velocity system using the Fractionation Software. Subsequently, using the ablation catheter, we explored the tagged sites and regions overlapping the GPs using conventional endocardial mapping



Video 2: Cardio inhibition induced by extracardiac vagal stimulation: transient asystole due to intense vagal effect.

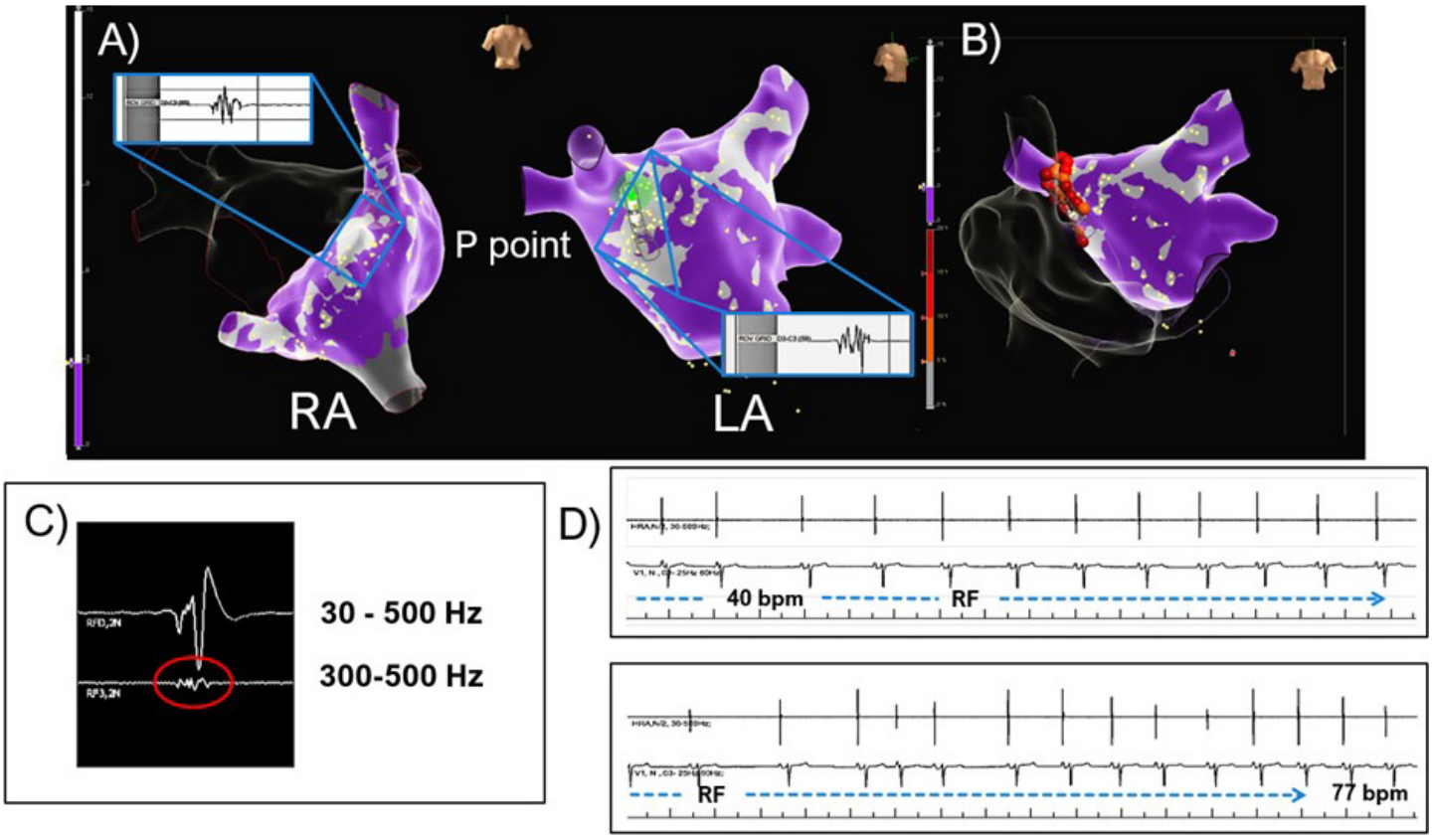


Figure 2: **The P area: an essential target in Cardioneuroablation. A) Fractionation map of the right atrium (PA) and left atrium (RAO) showing AF-Nests crowding, examples of fragmented EGMs (filter 40-500 Hz), characteristic of this area. B) Fractionation map (AP) and RF ablation lesions over the P area. C) Endocardial mapping using the ablation catheter, with typical high-frequency fragmented potential in channel 2 (circle), with filtered time domain recordings of 30 to 500Hz for conventional mapping and 300 to 500Hz for AF-Nest identification. D) Continuous ECG recording, upper-right, initial HR 40 bpm, the RF started causing acute vagal denervation resulting in an immediate gradual increase in HR from 40 to 77 bpm.**

looking for fragmented potentials as shown in **Figure 2**, using a 30 to 500 Hz filtered channel and a 300 to 500 Hz filtered channel.

At the initial stage, extensive ablation of the P area (triangular area between right PV insertion, left atrial roof, and fossa ovalis) was performed **(Figure 2)**, eliminating all AF-Nests in this area. Confirming the findings of previous work, this area typically presents numerous AF-nests, with an immediate response and significant increase in sinus rate during ablation, constituting an essential target in CNA.[3,23] During the following stage, ablation continues in the presumed anatomical sites of the four main GPs,[24,25,26] whose locations were facilitated by the accumulation of AFN. Prolonged RF applications (20 to 60 sec) were performed to achieve a thermal effect in the epicardial GP. The ECVS was repeated and, if there was no elimination of the vagal response, an expanded CNA was performed on sites with an accumulation of fractionated potentials in sinus rhythm, guided by fractionation map using a decapolar catheter Inquiry Afocus II (St. Jude Med, Ca, USA) and the multipolar catheter HD Grid Abbott (Abbott, Chicago, IL, USA), according to the original technique.[3,21] The ablation procedure was performed through an irrigated Flexability Abbott / Irvine (Abbott, Chicago IL, USA) catheter with a thermo-controlled system, and conventional power of 30 watts, and a duration of 20-60 sec in places defined by the combination of mapping techniques. During the applications, we observed the attenuation of the endo-cavitary electrograms, the change from fibrillar to compact pattern, the increase of the sinus heart rate (HR), and the improvement of the Wenckebach cycle.

CNA endpoints

After ablating each area related to the specific GP, the ECVS was repeated to check the degree of denervation. There was a gradual decrease in vagal response as the radiofrequency applications in the areas of the four main GPs were completed, until achieving complete elimination of the vagal response on the sinus node and atrioventricular node induced by ECVS **(Figure 3) (Video 3: Denervation control at the end of the CNA).** The assessment of vagal denervation was complemented by performing CSM at the site of the greatest vagal response identified at the beginning of the procedure. Finally, when the elimination or maximum reduction of vagal response was achieved, the Atropine test was repeated with an intravenous infusion of 2 mg, confirming the absence of an increased heart rate, which is the pharmacological confirmation of vagal denervation.

Statistical Analysis

Normality was tested using the Shapiro-Wilk test. Continuous variables are presented as mean ± standard deviation and were

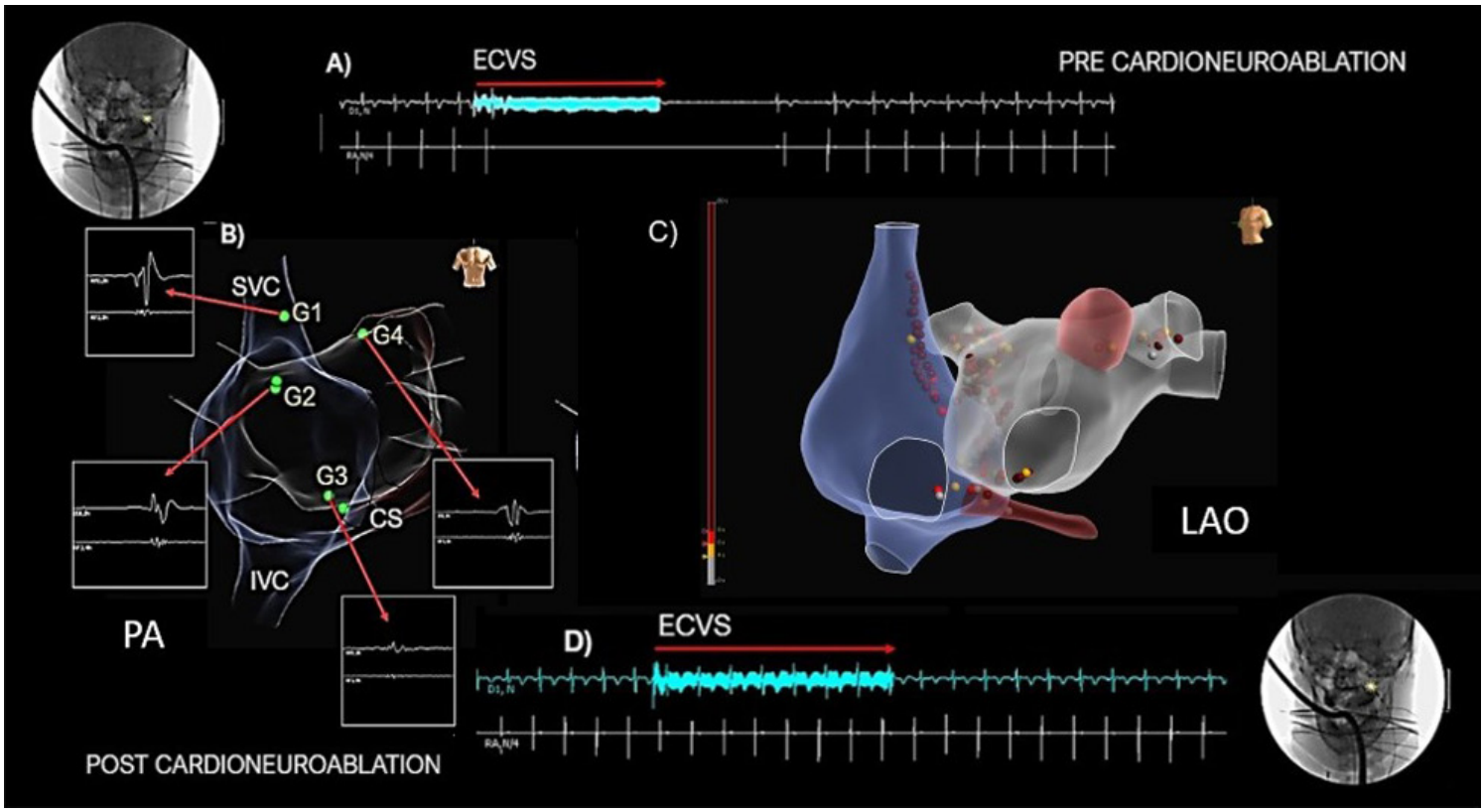
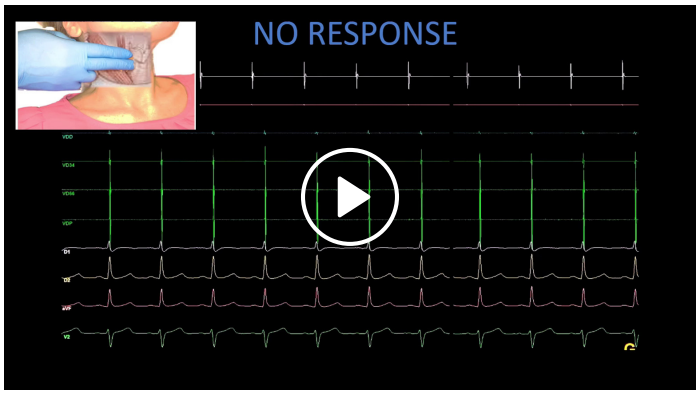


Figure 3: Comparison of intraoperative results pre and post-Cardioneuroablation. A) Fluoroscopy image with location of the quadripolar catheter in the left jugular foramen - ECVS pre Cardioneuroablation with induction of sinus arrest and transient asystole. B) EAM and recording of the characteristics of EGMs in the four main areas related to epicardial GPs. C) Set of RF lesions from the bi-atrial approach of Cardioneuroablation D) ECVS post Cardioneuroablation without induction of vagal response over sinus node and AV node - Fluoroscopy image with location of the quadripolar catheter in the left jugular foramen.



Video 3: Denervation control at the end of the Cardioneuroablation procedure. Carotid sinus massage under the same conditions before the CNA without induction of bradycardia or AV block. / ECVS without induction of bradycardia or AV block. Defining the end of the procedure - eliminating the pauses, bradycardia, or AV block previously induced.

analyzed using paired two-tailed t-tests. Categorical variables are presented as percentages and were analyzed using the $\chi 2$ test. The cumulative risk of syncope over time was estimated using the Kaplan-Meier method. All significance tests of normal variables were two-sided. $P \leq 0.05$ was considered significant. SPSS software for Windows (version 16.0.0, SPSS Inc., Chicago, IL, USA) was used for statistical analysis.

Results

A total of eight patients with repetitive sinus pauses caused by CI induced by activities related to neck rotation and hyperextension movements were included, three female and five male patients, with mean age 58.6 years (± 11.8), without significant structural heart disease, and LVFE% 67.8% ± 2.5%. At the CSM we observed sinus pauses lasting 5.7 sec (± 0.7 secs), and transient AVB in three of the eight patients, without concomitant hypotension after atropine infusion, blood pressure was measured by a non-invasive blood pressure monitor, a beat-to-beat monitor was not available during the electrophysiological study, confirming the presence of an important cardioinhibitory component. All patients had repetitive episodes of syncope, with a mean of 7.6 episodes (± 6.2) in the 12 months prior to study inclusion.

As an immediate result of CNA, an increase in **HR (58.9 ± 12.7 / 81.8 ± 4.9 bpm - p: 0.0012) (Figure 4)** and Wenckebach cycle **(133.5 ± 39.2 / 164.7 ± 10.8ppm)**, **p: <0.01** was obtained in all patients. The vagal response induced by ECVS, and CSM was eliminated. At the end of CNA, the absence of response to intravenous infusion of Atropine (2 mg) was confirmed. The

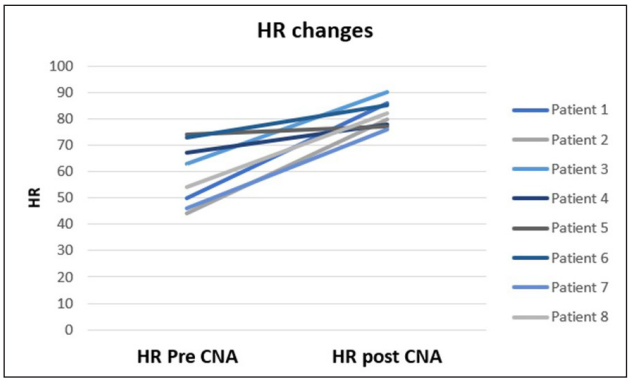


Figure 4: **Effect of the Cardioneuroablation on heart rate. Comparison between Pre-ablation and post-ablation HR was highly significant P=0.0012.**

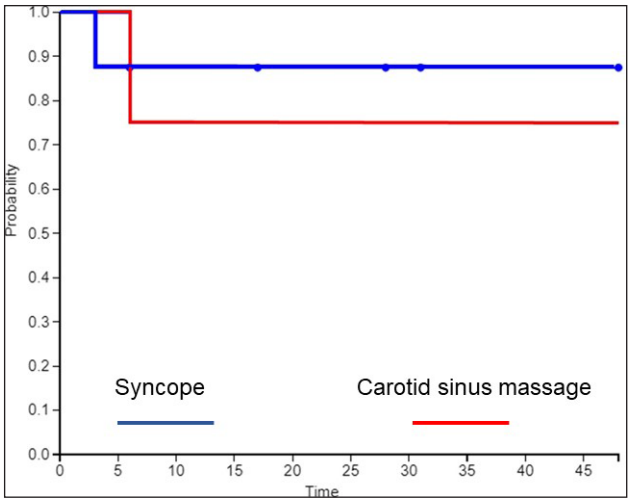


Figure 5: **Kaplan-Maier curve: showing the evolution of events of spontaneous syncope and cardioinhibitory response to carotid sinus massage post-Cardioneuroablation, in a long-term follow up.**

maximum level of vagal denervation was obtained and confirmed by three methods of objective endpoints: ECVS, CSM, and atropine.

Cardioinhibitory response to CSM was cleared acutely in all patients. The long-term response to CSM post-CNA remained absent in six out of eight patients **(Figure 5)**. A significant pause of **six** seconds, induced by right CSM was observed in one patient after six-month follow-up, but no spontaneous syncopal events were recorded. In this case, even without symptoms and for safety reasons, the attending physician recommended the implantation of a dual-chamber pacemaker with a left bundle branch ventricular electrode via an interventricular transseptal approach, with rate drop response (RDR). A peculiar fact of this patient was that during CNA the end point of elimination of the ECVS-induced vagal response was not achieved with ablation of the P area and the four areas of the main GPs, and it was necessary to perform additional ablation in alternative locations guided through the fractionation map in the Waterstone groove **(Figure 6)**, obtaining elimination of the ECVS-induced vagal response at the end of the procedure, as well as the response to CSM and infusion of atropine.

In one patient, a restricted CNA was required for exclusive sinus node denervation, reaching the endpoints of the absence of response to CSM and the atropine test, and elimination of the response to ECVS on the sinus node. However, the response over the AV node persisted, with induction of high-grade AV block during vagal stimulation. The patient had a recurrent syncope three months later, this time with CI effect exclusively over the AV node, resulting in a high degree AVB. Further clinical investigation including CSM reproduced the spontaneous findings of transient AVB correlated with symptoms. This response was eliminated after the atropine test, with no increase in sinus HR. Subsequently, a second CNA procedure was performed, achieving complete elimination of the vagal AV node response. The maximum denervation was achieved guided by ECVS. The patient has remained asymptomatic for the last 20 months.

The eight patients completed the follow-up period longer than 12 months, with a mean follow-up duration of 31 months (±16.1), systematically followed up with clinical visits at one, six, and 12 months, with CSM performed during the visits. After this period, annual follow-up was performed in the office or by telephone contact to record any recurrence of syncope or pre-syncope episodes. Repetitive syncope events were eliminated in **87.5%** of the patients.

There were no intraoperative complications related to vascular access, transseptal puncture, ECVS, transesophageal echocardiography, radiofrequency ablation, or the performance of CSM in the pre-CNA and post-CNA periods.

Discussion

The neurocardiogenic syncope related to CSS is a cause of sudden and transient loss of consciousness, sometimes underdiagnosed and hard to solve definitively. The symptom may occur with few or no prodromal symptoms, making it difficult to prevent physical trauma caused by falls.[27] Drug maneuvers and therapies have little effect in reducing syncope, and pacemaker implantation is the currently recommended therapy for patients with repetitive syncopal episodes with significant CI.

Based on the CNA, proposed by Pachon et al.[3] in 2005, describing vagal denervation through RF ablation of AFN in the atrial walls, we proposed this study aiming to attenuate the cardioinhibitory reflex in patients with CSS by eliminating postganglionic parasympathetic fibers and neurons in the atrial walls and ganglionic plexuses. This proposal was already included in the original study but had not yet been tested. The objective is to evaluate the efficacy and safety of CNA as an alternative to pacemaker implantation in patients affected by CSS refractory to clinical treatment.

The selection of patients was carefully performed, including only very symptomatic cases, with significant cardioinhibitory response, with repetitive syncopes, with a frequency greater than five events in the 12 months prior to recruitment, and after confirmation of the

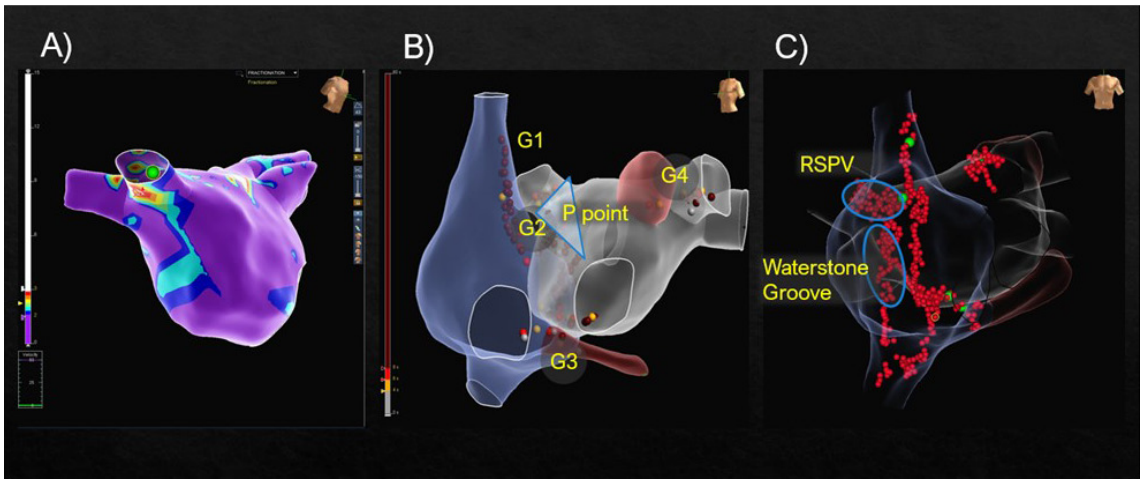


Figure 6: **A) EAM map, fractionation map. B) Lesion Set of RF ablation on the four main areas related to GPs. C) RF applications at alternative sites identified by the fractionation map on the Waterstone groove and enlarged ablation in the anterior surface of right superior pulmonary vein.**

etiology of the reflex syncope by abnormal carotid sinus baroreceptor response and abolition of the cardioinhibitory response when tested with Atropine infusion.

Previous case studies reported the effectiveness of CNA in the treatment of CSS, with a significant reduction in syncope recurrence, resulting in an increased sinus rate and negative response to CSM and post-CNA atropine test.[12,13,14,15] These analyses suggest the applicability of CNA in patients with CSS, generating hypotheses, identifying potential lines of research, and proposing technical variants that will be of extreme value for common sense and to elaborate more robust information.

The main goal of the CNA procedure is to achieve important long-term attenuation of the vagal response by weakening or eliminating the efferent cardioinhibitory component of the vagal reflex triggered by carotid stimulation.

Using ECVS, we observed a gradual decrease in the vagal cardioinhibitory response over the sinus node and AV node. The ablation was continued until the complete elimination of asystole and/or AVB in seven out of eight patients, defining the absence of vagal response to ECVS as the endpoint of the procedure, thus limiting excessive ablation. Additionally, the elimination of the response to CSM was confirmed, and as a last step, the absence of an increase in HR to intravenous infusion of atropine.

We should consider that in the acute phase, there is a significant increase in heart rate, however, in the long term, HR gradually decreases due to the progressive reduction in sympathetic tone and a certain degree of vagal reinnervation, thus restoring the autonomic balance.[28] The optimized result after ECVS and CSM guided CNA can minimize this natural evolution of re-innervation and prevent long-term recurrences.

Although vagal innervation is present throughout the atrial wall, CNA is initially directed to the P-point and to the anatomical sites of the presumed ganglionic plexuses 1, 2, 3, and 4 at which there is a greater density of innervation: *Area 1* at the junction of the superior vena cava and RA, *Area 2* at the junction of the right pulmonary veins with the left interatrial septum, *Area 3* at the junction of the inferior vena cava with the RA, with the posterior septal space of the LA and the coronary sinus roof and *Area 4* at the posterior and superior aspect of the left pulmonary veins. At these points, the goal is to achieve deep, transmural heating and extra-cardiac effect at the level of the ganglionic plexuses, generating effective and long-lasting parasympathetic denervation, resulting in the elimination of the cardioinhibitory reflex and cardioinhibitory syncopes.

Radiofrequency ablation, on the other hand, eliminates the most elementary level of vagal innervation by destroying the postganglionic neuronal bodies of the efferent arm of the parasympathetic system significantly reducing the extent and likelihood of reinnervation.[28]

With confirmation of vagal denervation with ECVS, it is possible to achieve a maximum degree of acute denervation certainly contributing to avoid possible long-term recurrences.[20] Additionally, when there is still residual vagal response, mapping and ablation of remaining AFN are fundamental to increase the denervation degree. In this sense, besides the P-Point and the areas related to the four main GPs are treated, for example, the Crista terminalis, the Waterstone groove, and the area of Marshal's ligament. Naturally, in CNA without control of the vagal response, this complementation would not be possible.

The second parameter to control vagal response is CSM. It is less objective than the ECVS because it has lower reproducibility and is a maneuver that should be avoided due to the possible risk of vascular complications. In this study, it was used with great care in this very select group of patients who had no apparent carotid vasculopathy. However, the presence of CSS alone denotes the presence of pathology in the vascular wall, even if there is no luminal reduction.

A relevant finding was the absence of complications in this group, both when performing CNA as well as in the CSM performed before, during ablations, and in long-term follow-up.

The neurocardiogenic syncope caused by carotid baroreceptor stimulation was completely abolished as well as the response to extra-cardiac vagal stimulation through parasympathetic denervation, allowing confirmation of the effect of vagal denervation in an objective way, preventing syncope episodes during a long-term follow-up, the result of this analysis was satisfactory with optimal follow-up time, decreasing the need for pacemaker implantation and giving back quality of life to the patients. Pacemaker implantation was avoided in 87.5% of the patients.

In this series of eight patients with cardioinhibitory CSS, we demonstrated that CNA can be considered an effective and safe alternative compared to pacemaker implantation. The use of response to ECVS and CSM as objective endpoints allowed us to define the optimal vagal denervation effect by eliminating the response in all patients and were equivalent to the absence of HR increase to intravenous atropine infusion. The denervation effect was sufficient to prevent new episodes of syncope or long-term pre-syncope, with no significant complications or adverse effects reported.

Conclusion

In this group of patients, CNA was highly effective in preventing the recurrence of syncope. These patients had no significant heart disease, but they had very symptomatic CSS that did not respond to clinical treatment, and they also had a significant CI in the CSM, which was eliminated by CNA in the long term. As a result, most of the patients studied did not need pacemaker implantation.

Abbreviations

AVB – atrioventricular block
CI – cardiac inhibition
CNA – Cardioneuroablation
CSM – Carotid sinus massage
CSS – Carotid sinus syndrome
ECVS – extra cardiac vagal stimulation
GP – Ganglionic plexuses
HR – Heart rate
RF – Radiofrequency

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Conflicts of Interests

The authors have no conflicts to disclose.

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