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CHARACTERIZATION OF HEART RATE VARIABILITY DURING TOTAL VENOUS ANESTHESIA: A CASE REPORT

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Abstract: The aim of the study was to characterize the heart rate variability in a patient with no comorbidities, submitted to buccomaxillofacial surgery under total venous anesthesia using the linear frequency and nonlinear methods in the chaos domain (Poincaré plot). Data collection was performed before, during and after the surgical procedure using a Polar V800 cardiofrequencymeter and subsequently analyzed and filtered using the Kumbios HRV 3.0 software. During propofol infusion, elevations in LF, HF, SD1 and SD2 were observed. The LF/HF ratio showed obvious changes, which were found to be maximal during extubation and submaximal during awakening under greater influence of the sympathetic nervous system. The moment of the incision has parameters similar to those of rest. Final surgery maintenance showed the lowest values of LH/HF and SD1/SD2, with lower LF and SD2 values compared to rest. During the awakening, there was a decrease in SD1 and HF, representing the moment of greatest fragility during the total venous anesthesia, being of fundamental importance future studies about their repercussions.

Keywords: heart rate variability, total venous anesthesia and autonomic nervous system.

Introduction

Autonomic regulation is the substrate for a series of events in the body, ranging from a narrow cellular signaling, to triggering impulses of events in the circulation and organs, thus sympathetic and parasympathetic influence occurs in the sense of homeostasis between the two pathways and the adaptive regulation of systems to the needs imposed (Jeppesen, 2016).

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The autonomic nervous system (ANS) has two subdivisions: sympathetic ANS and parasympathetic ANS which have complementary actions that counterbalance, contributing to the maintenance of homeostasis. (Nunes et al, 2007).

The sympathetic stimulus occurs through the synapse between the autonomic fibers of the spinal cord, the intervetabral columns, the paravertebral ganglia, ending with the release of epinephrine, which in contact with the adrenergic receptors promotes tachycardia and vasoconstriction, raising blood pressure and increasing cardiac work; similarly, the parasympathetic stimulus runs through the vagus nerve, resulting in the synapse of vagal fibers with the intracardiac ganglia. Thus, the heart presents itself as an organ with rapid repercussion of autonomic activity, being one of the main ways of monitoring, and evaluating the effectiveness of ANS actions, as well as its modulation for the benefit of the patient in medical practice (Biaggioni, 2017).

As a measure of indirect evaluation, there are semiological maneuvers that evaluate the cardiac responsiveness to SNA stimulation, understandable from the moment of the evaluation of the baroceptor reflex via Valsalva Maneuver, for example, considering that a sudden increase of pressure promotes activation of localized baroreceptors in the carotid sinus that transmit a signaling to the brainstem to inhibit the adrenergic pulse, generating vasodilation and blood pressure normalization. It is very important to remember that patients with cardiovascular alterations such as coronary artery disease, hypertension, infarction and heart failure present a decrease in the sensitivity of this mechanism of ANS regulation, which, by itself, already increases the risk factors for death due to cardiovascular disease (Ranucci, 2017). Another variant of the parasympathetic effect would be the Occulocardiac reflex: the chemical-mechanical stimulation of the third cranial pair signals the vagus nerve to propagate a cholinergic discharge, which reflects semiologically in hemodynamic changes, such as heart rate and mean arterial pressure drop (MAP), apnea and gastric hypermotility (Meuwly, 2017).

From the anesthetic point of view, in surgical procedures in which the best proposal is general anesthesia, it is necessary to maintain the airway, with orotracheal intubation being the method of choice to assure it (Biaggioni, 2016); However, during this procedure, there is an important sympathetic discharge, secondary to the stimulation of the laryngeal autonomic innervation during laryngoscopy, which can generate important systemic effects, impacting the patient's survival according to their comorbidities, which makes this characteristic something to be remembered from anesthetic practice to emergency practice, during rapid sequence intubation procedures (Martins, 2015).

The knowledge that heart rate fluctuations reflect the sympathetic and parasympathetic nervous system interaction has provided a window for the study of the autonomic nervous system from the analysis of heart rate variability (Ribeiro; Filho, 2005). In normal adults, the heart rhythm is not strictly regular, presenting periodic and physiological fluctuations known as heart rate variability (Corrêa, 2010). Heart rate variability (HRV) is described as an oscillation between two consecutive beats (R-R interval) constituting a simple and non-invasive electrocardiographic method of measuring autonomic impulses (Vanderley, 2009). It is used as a marker of autonomic heart modulation (Hsu, 2012).

HRV patterns modifications represents a sensitive and early health commitment indicator. A high heart rate variability is a sign of good adaptation, characterizing health and efficient autonomic mechanisms. While low variability indicates, in most cases, inadequate autonomic mechanisms due to pathologies or aging (Vanderley, 2009).

The determination of HRV has been widely used as a research tool for the autonomic nervous system (Moraes Filho, 2005). HRV indices can be captured by electrocardiographs (ECG), analogue digital converters or cardiofrequency meters - the latter being more accessible and accurate, being performed by a band with electrodes on the patient's chest, picking up the electrical impulses of the heart that will be analyzed and filtered by a software (Vanderley, 2009).

The methods used for HRV analysis include statistics (in the time domain), spectral power (in the frequency domain) and nonlinear geometric analysis such as the Poincaré plot. (Hsu, 2012).

Time domain analysis quantifies heart rate changes over time or intervals between normal cycles, while the frequency domain describes periodic heart rate oscillations by providing information about the relative intensity of these oscillations in cardiac sinus rhythm. (Sztajzel, 2004).

Frequency domain methods are classified into two componets. The low frequency component (LF) ranges from 0.04 to 0.15Hz and is associated with the joint action of sympathetic and parasympathetic activities, but with a sympathetic predominance. The high frequency component (HF) varies between 0.15 and 0.4 Hz, correlates with the respiratory signal and is considered a marker of parasympathetic activity. The LF/HF ratio acts as an indicator of the heart sympatovagal balance (Vanderley, 2009).

Heart rate variability, modulated by ANS, exhibits a non-linear behavior (Godoy, 2003). The Poincaré plot is a nonlinear and geometric method to analyze the HRV dynamics. Its analysis can be done qualitatively (visual) by the evaluation of the figure formed by the plot attractor, which is useful to show the R-R intervals complexity degree. A plot is considered normal when it acquires characteristics of a comet, in which a R-R intervals beat-to-beat dispersion increase is observed with the R-R intervals increase. Another way of evaluating the plot would be quantitative by means of adjustments of the ellipse of the figure formed by the attractor from which three indices SD1 are obtained that represent the dispersion of the points perpendicular to the line of identity being considered an index of instantaneous record of the variability beat to beat; SD2 represents the dispersion of points along the identity line representing the HRV in long-term records and the ratio between the two (SD1 / SD2) shows the ratio between the short and long variations of the RR intervals. (Vanderley,2009). SD2 of the plot is correlated with an overall HRV variability (sympathetic modulation and parasympathetic tone, predominantly sympathetic), and SD1 with the pure measure of parasympathetic activity or respiratory sinus arrhythmia (Brennan et al., 2002). The ratio between SD2 and SD1 sets the balance between the sympathetic and the parasympathetic (Guzik et al., 2007).

The figure below shows a poincaré plot at rest of the evaluated patient.

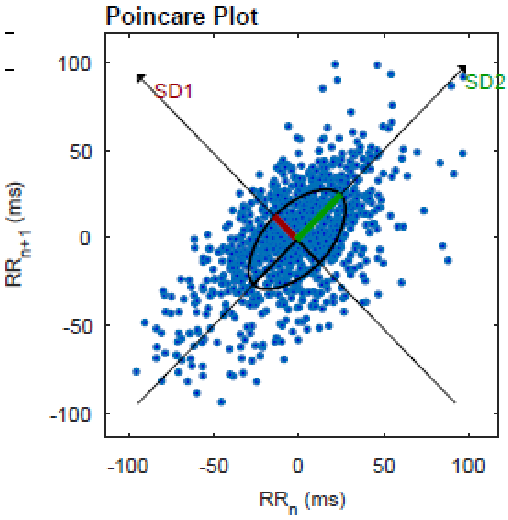

Figure 1: Poincaré chart of the patient at rest. Source: author's file.

The Poincaré plot offers better visual monitoring capability to detect changes in autonomic dynamics during anesthetic procedures (Hsu, 2012).

General anesthesia uses drugs that contribute to its safety, as they depress the autonomic nervous system in order to suppress excessive sympathetic activity evoked during surgical procedures. Sympathetic activity attenuation during general anesthesia is assessed by monitoring changes in blood pressure and/or heart rate (Riznyk, 2005). A study by Matchett (2014) has shown that general anesthesia was associated with a marked loss of normal variability.

Some studies correlating HRV with general anesthesia have found that induction with remifentanil decreases HRV (Luginbühl, 2007). Propofol reduced HF in a manner dependent on the hypnosis degree (Kanaya, 2003). Fentanyl reduced total potency and LF, but not HF, indicating a greater sympathetic activity reduction. Thiopental and propofol led to a greater reduction of HF and cardiac variability. With thiopental there was an increase in LF and LF/HF ratio, indicating that the vagolytic effect is more associated with increased sympathetic activity. With propofol the LF component has been conserved, indicating that the parasympathetic activity is more diminished than the sympathetic activity (Riznyk, 2005).

In a randomized study comparing anesthesia with sevoflurane / remifentanil versus propofol / remifentanil, Ledowski et al (2005) noted an increase in LF / HF and total potency in the propofol / remifentanil group and concluded that the combination of sevoflurane and remifentanil seems to cause more sympathetic activation. The present article aims to characterize the heart rate variability in a patient undergoing buccomaxillofacial surgery under total venous anesthesia using the linear method in the frequency domain and the nonlinear method in the domain of chaos, fractality and complexity - the Poincaré plot

Methodology

The present study is a descriptive study in the form of a case report, performed on 05/19/2017 in a tertiary hospital in the interior of Ceará-Brazil, with population and sample composed of one (01) male patient, natural and from Juazeiro do Norte with diagnostic hypothesis of zygoma fracture and submitted to bucomaxillofacial surgery under total venous anesthesia. Data collection was performed before, during and after the surgical procedure using a Polar V800 cardiofrequency meter and subsequently analyzed and filtered using the Kumbios HRV 3.0 software. In order to characterize heart rate variability during total venous anesthesia, two methods were used: the linear in the frequency domain and the non linear in the chaos domain, the Poincaré plot.

The assessment and analysis of the medical record was made exclusively with the patient's knowledge and documentary authorization, as well as documentary authorization of the faithful custodian of the medical records of the hospital in which the surgical procedure was performed (ANNEXES). The patient's identity was duly preserved and the research reflected the ethical considerations of the National Health Council Resolution 510/16 regarding studies with human beings, being guaranteed the anonymity of the subject involved in the research, and with the project submitted to the Committee of Ethics and Research selected by Plataforma Brasil.

A bibliographic search was carried out for the theoretical basis of this article, in which Pubmed and Scielo databases were used as search tools, using the descriptors: "heart rate variability", "autonomic nervous system" and " total venous anesthesia"; These terms were searched alone and associated.

The risks are the specifics of the procedure and the researcher took the necessary care to ensure the safety of these documents and omit personal data that could identify the patient, minimizing the greater risk that would be the embarrassment.

The expected benefits of the study include improving medical knowledge about the proposed theme and its relevance promising for its potential impact on the natural history of disease.

Case Report

V.H.L.N., male, 22 years old, 67 kg, 1.76 cm, without comorbidities, ASA I, arrives at the reference hospital presenting a zygomatic fracture. The patient underwent surgical treatment on 05/19/2017, under total venous anesthesia, with nasotracheal intubation, without intercurrences. Induction was done with intravenous remifentanil and 1% intravenous propofol and intravenous cisatracurium. Anesthetic maintenance was performed with propofol and remifentanil in continuous infusion and ketamine. No hemodynamic, cardiovascular or temperature changes were observed during the procedure. During the surgical manipulation, the presence of the oculo-cardiac reflex was observed, characterizing sinus bradycardia. After surgery, the patient was referred to the post anesthetic recovery room, remaining hemodynamically compensated without vasoactive drugs.

In order to measure heart rate variability throughout the procedure, a Polar V800 cardiofrequencymeter was used. A brace with electrodes that pick up the heart's electrical impulses was placed in the patient's chest and subsequently subjected to analysis and filtering by Kubios 3.0 software.

The patient arrived at the pre-anesthetic evaluation room at 7:15 am, and the parameters were measured before the anesthetic procedure, with systolic blood pressure of 109mmHg and diastolic blood pressure of 60mmHg, axillary temperature of 20.4 ℃ and heart rate of 79bpm.

All records collected by the cardiofrequencymeter during the procedure are shown below, in figure 2:

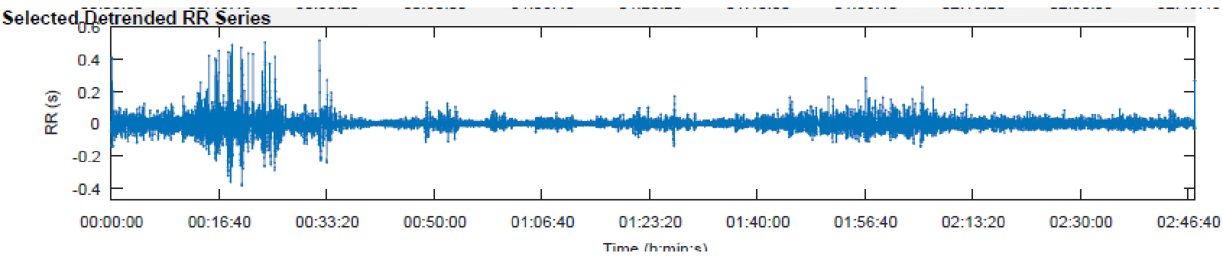

Figure 2: Tachograph of RR intervals collected from the patient under study by the Polar V800 cardiofrequency meter and filtered by Kumbios 3.0 software. Author archive.

Results

4.1 Heart rate variability characterization in the chaos domain - Poincare plot.

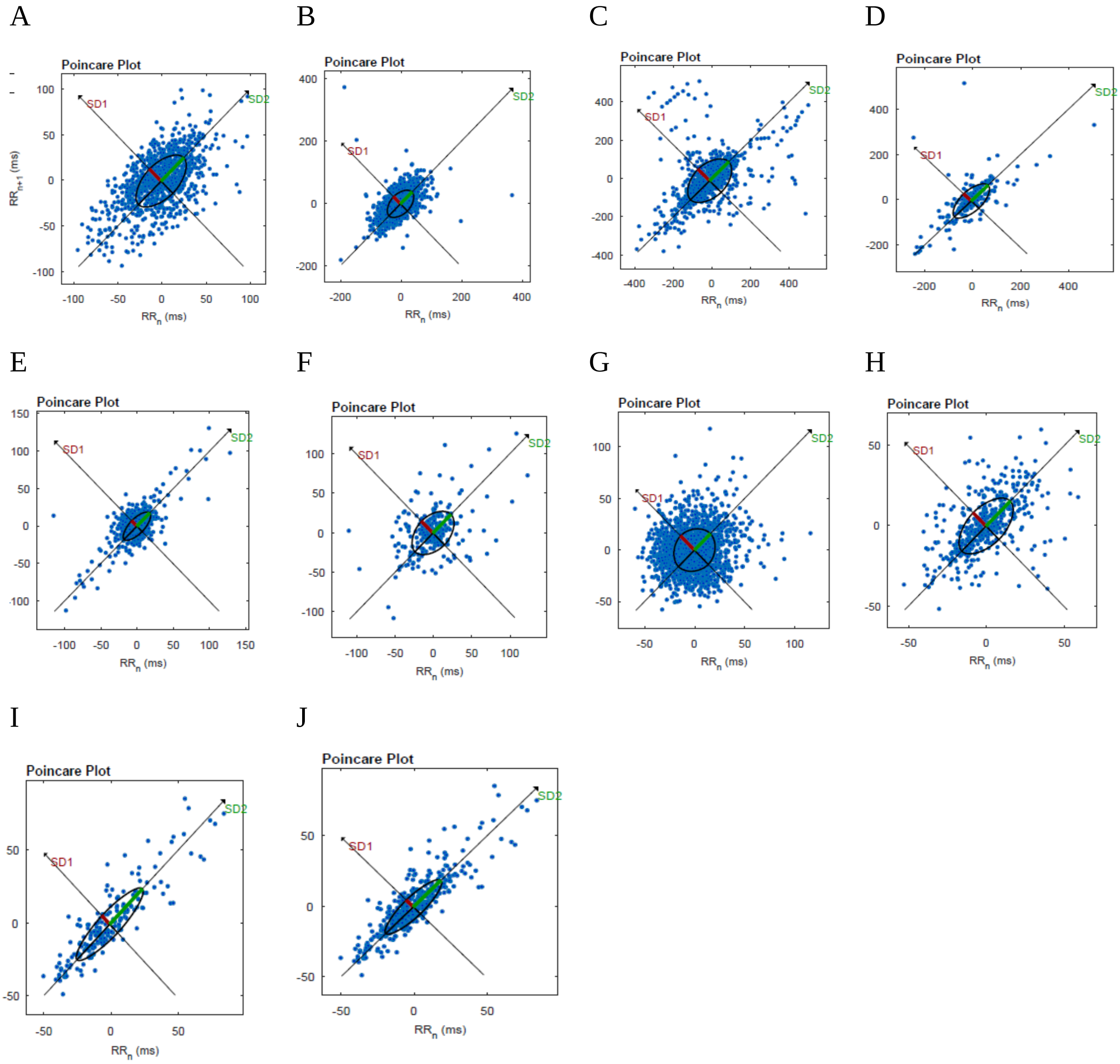

Figure 3: Poincaré chart of the patient: A. Resting, B. Remifentanil infution, C. Propofol infution, D. Intubation, E. Infusion before incision, F. Incision, G. Final maintenance of surgery H. End of infusion before extubation , I. Awakening, J. Extubation. Source: author's file.

4.2 Heart rate variability characterization in the frequency domain.

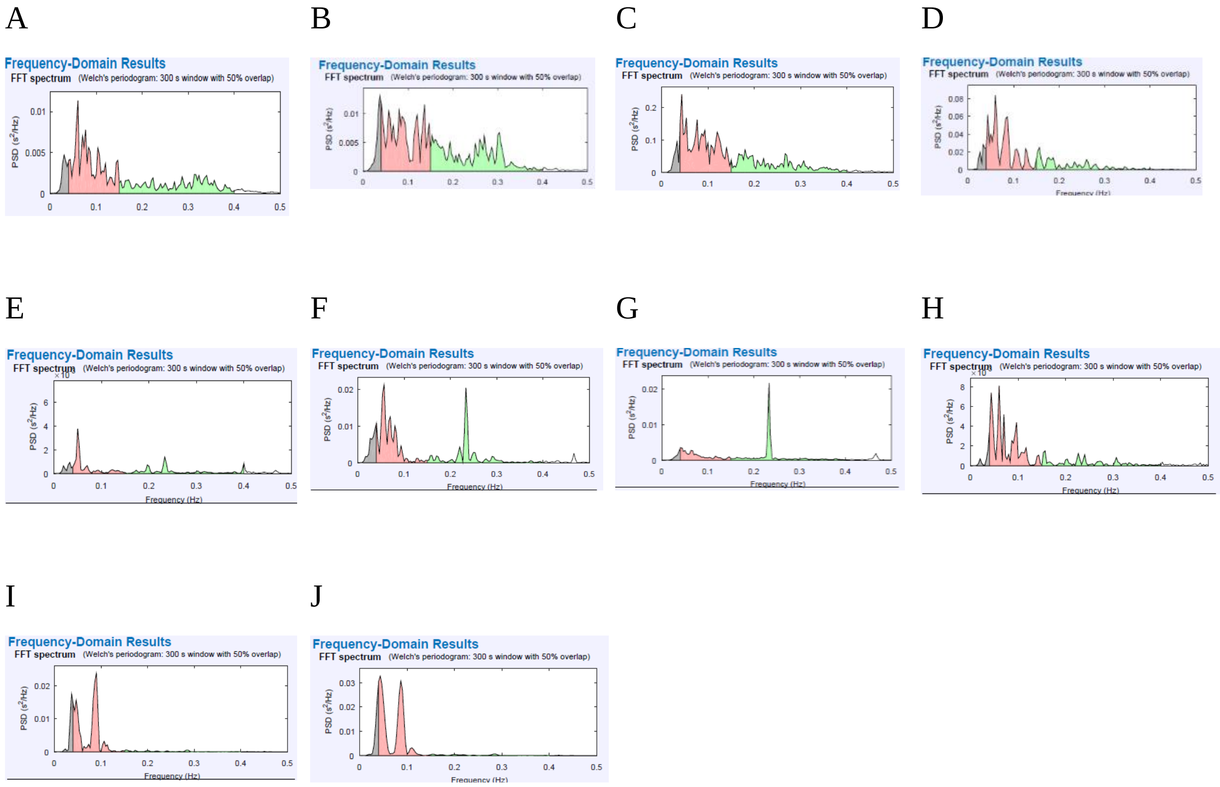

Figure 4: Graphical representation of HRV in the frequency domain of the patient: A. Resting, B. Remifentanil infution, C. Propofol infution, D. Intubation, E. Infusion before incision, F. Incision, G. Final maintenance of surgery H. Final of the infusion before extubation, I. Awakening, J. Extubation. Source: author's file.

4.3 Heart rate variability quantitative characterization taking into account the Poincaré plot and the frequency domain.

Table 1: Power spectral indexes (LF, HF, LF/HF) and Poincaré plot indexes (SD1, SD2, SD1/SD2).

	Rest	Induction		Intubation	Pre-incision	Incision	Surgery final maintenance	End of pre-extubation infusion	Awakening	Extubation
		Remi-fentanil	Propofol							
LF	413	7727	10043	2577	447	4510	136	210	523	882
HF	255	6600	5585	960	36	299	204	63	26	35
LF / HF	1.624	1.210	1.798	2.684	1.332	1.708	0.666	3.340	20.234	25.057
SD1	18.8	32.3	84.9	44.9	10.2	21.2	19.5	11.7	6.9	8.3
SD2	36.3	53.9	139.9	98.9	25.1	33.4	22.5	22.0	26.6	34.4
SD1/SD2	1.934	1.668	1.648	2.203	2.452	11.575	1.153	1.875	3.874	4.161

LF: Low frequency, sympathetic predominance
HF: high frequency component, parasympathetic marker
LF / HF: Sympathetic vagal balance over the heart
SD1: Perpendicular, beat to beat. parasympathetic
SD2: Long-term heart rate variation. Global sympathetic
SD2 / SD1: Relation between short and long range. Balance between sympathetic and parasympathetic.

4.4 Heart rate variability characterization during total venous anesthesia

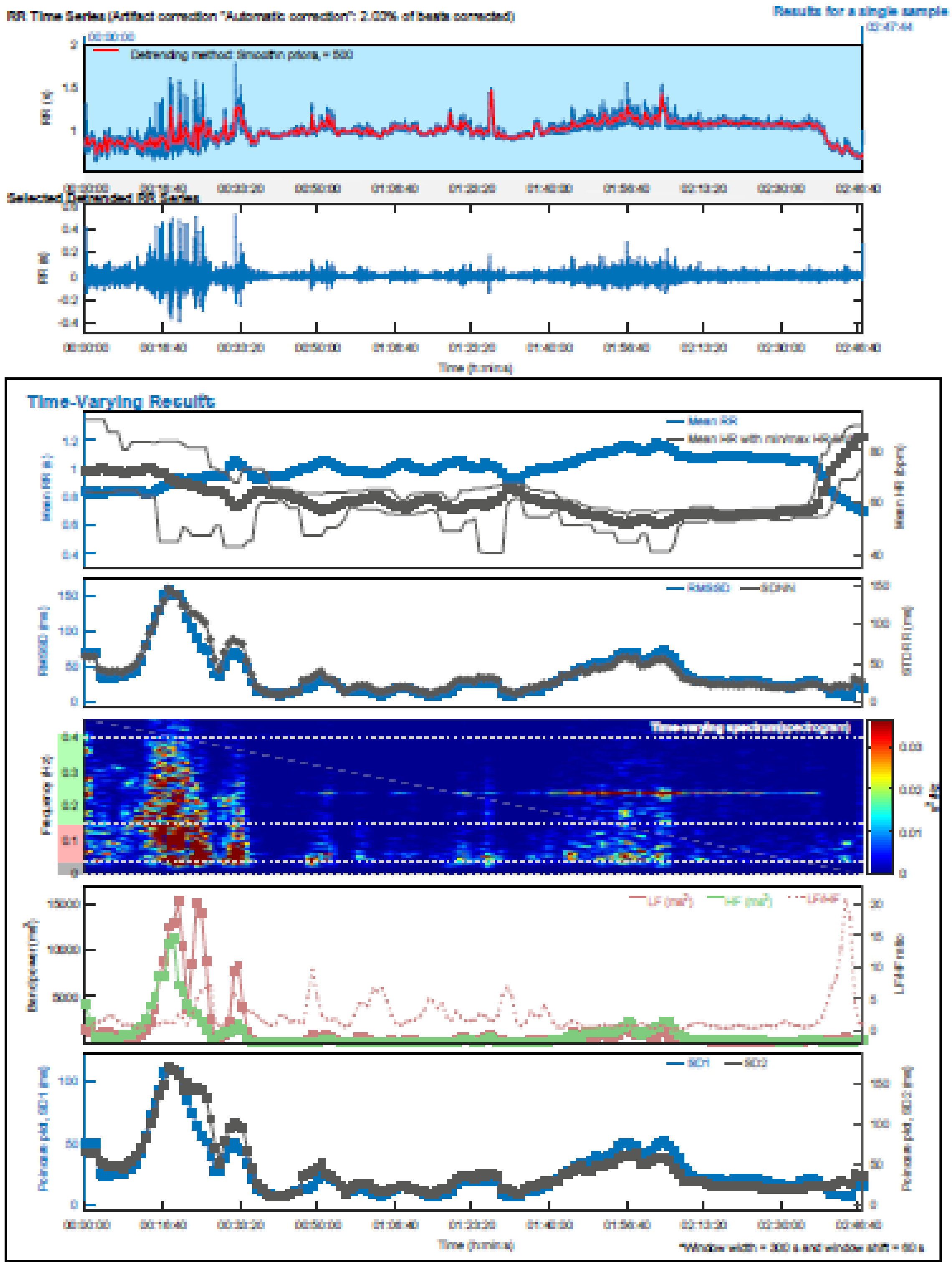

Figure 5: HRV recording in the frequency domain and the Poincaré plot of the studied subject. Author archive.

Discussion

The total venous anesthesia had two moments, the induction was done with intravenous remifentanil and 1% intravenous propofol and intravenous cisatracurium and the anesthetic maintenance phase with propofol and remifentanil in continuous infusion.

Analyzing Figure 3, the SD1 index, which represents the transverse axis of the Poincaré plot, shows the standard deviation of the instantaneous beat-to-beat heart rate variability and indicates the parasympathetic influence on the sinoatrial nodule. Initially remifentanil was made and soon after propofol, there was a greater parasympathic influence compared to the other surgical times, denoting a moment of fragility, emphasizing the importance of a well-conducted and balanced anesthesia. At the end of pre-extubation there was greater influence of both systems. There was a sympathetic response predominance in surgical times, that is, there was an overall stimuli reduction during intubation; parasympathetic activity reduction over the sympathetic during infusion prior to incision, awakening, and extubation; the final surgery maintenance was similar to the resting state; and there was a greater parasympathetic stimulation observed during the infusion of propofol.

In our study we obtained the highest values of LF, HF, SD1 and SD2 during infusion of propofol (figure 4 and table 1). The LF / HF ratio showed obvious changes, which were found to be maximal during extubation and submaximal during awakening under greater sympathetic nervous system influence, being characterized in figure 5. The moment of the incision has parameters similar to those of rest, proportionally, expressed with a smaller sympathetic and parasympathic balance. Final surgery maintenance showed the lowest LH / HF and SD1 / SD2 values, with lower values of LF and SD2 in relation to rest. During the awakening, there was a decrease in SD1 and HF demonstrating a moment of high fragility during the total venous anesthesia, being an important theme for future studies.

Conclusion

Anesthesia is considered by some authors as the Medicine of the Autonomic Nervous System. All drugs and techniques that induce the anesthetic state modulate, in some way, the ANS. Heart rate variability has been proposed in light of the current evidence as an important tool in the detection of small autonomic alterations, and it can be used for anesthetic monitoring and is therefore a promising area of research to evaluate its real impact.

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