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Anesthesia with propofol slows atrial fibrillation dominant frequencies☆

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Abstract

The mechanisms responsible for the maintenance of atrial fibrillation (AF) are not completely understood yet. It has been demonstrated that AF can be modulated by several cardiac diseases, the autonomic nervous system and even drugs with purportedly no antiarrhythmic properties. We evaluated the effects of a widely used anaesthetic agent (propofol) in the fibrillation patterns. Spectral analysis was performed over atrial electrograms at baseline and immediately after a propofol bolus. Only after performing principal component analysis (PCA), we were able to significantly detect that propofol slows AF.

Keywords: Atrial fibrillation; Anaesthetic; Principal component analysis (PCA)

1. Introduction

Atrial fibrillation (AF) is the most common arrhythmia in clinical practice, with a prevalence rising nearly to 10% in the elderly [1]. AF is an arrhythmia originated at the atria (the upper heart chambers), and is due to the coexistence of multiple re-entrant atrial wavelets instead of a single one per cardiac beat. AF is often initiated by arrhythmogenic foci located at the pulmonary veins [2,3]. Abnormal electrical activity from those foci may induce AF. During AF, the atria beat irregularly and usually exceeding 350 local beats per minute, causing ineffective contractions of the atria and reducing its ability to pump blood into the ventricles.

Since AF is associated with elevated ventricular heart rates, which may become symptomatic, cardiologist have to decide between just decreasing heart rate or terminating the arrhythmia. Restoration of normal sinus rhythm can be achieved rapidly either by pharmacological or electrical cardioversion. Once in sinus rhythm, in order to prevent the recurrence of new AF episodes, cardiologists prescribe antiarrhythmic drugs and/or perform more complex AF ablation procedures burning specific areas within the left atrium (LA) [4–6]. During the latter procedures, multiple intraatrial electrical signals (electrograms) can be recorded simultaneously, providing an interesting source of data to get insight into the mechanisms of AF.

During electrical cardioversions and catheter ablation procedures (and sometimes performing some other cardiac electrophysiological studies), patients are typically under the influence of anaesthetic agents. The most common agent is propofol (2,6-diisopropylphenol) which is a rapidly acting intravenous anaesthetic. The rapid redistribution and metabolism of propofol results in a short elimination half-life of approximately one hour, making it suitable for short-lasting sedation. A propofol bolus might alter atrial electrical activity during AF, but it still remains unknown.

During AF ablation procedures, simultaneous atrial electrograms can be recorded. Local electrograms may provide useful information reflecting the electrophysiological processes that mediate AF. Typically, intracardiac electrograms in AF constantly change timing and morphology, reflecting the irregular and complex activation in the atria. When the signals are collected from a pair of closely spaced electrodes, they are called

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bipolar electrograms, which measure the differential voltage between the two electrodes. This differential measurement is equivalent to a spatially high-pass filtered version of the underlying activation traversing the two electrodes. Thus it is sensitive to the direction of nearby depolarization and repolarization wavefronts.

The most common parameter evaluated from atrial electrograms is the local AF cycle length, being the inverse of the local dominant frequency of the fibrillatory waveform. This parameter is related to atrial refractoriness if conduction velocity remains unaltered [7–9].

The analysis of AF electrograms may provide information about the underlying psychopathological substrate. The common algorithm used in electrograms analysis was described by Botteron [10] and is based on the absolute value of the original electrogram. In this transformation the atrial electrograms are filtered (bandpass, 40–250 Hz, zero-phase, third-order Butterworth filter) to remove baseline shift and high-frequency noise. Then, the absolute output value of the bandpass filter is low-pass filtered using a similar third-order Butterworth filter with a 20 Hz cut-off). This process extracts a time-varying waveform proportional to the amplitude of the high-frequency components of the original atrial electrograms. Since the localized intracardiac electrograms recorded during the procedure are a mixture of both local and global cardiac activity, it can be difficult to distinguish overall trends. Therefore, we propose to use principal component analysis (PCA) to enhance the characterization of the fibrillatory patterns, summarizing the data using a smaller number of components and rejecting background noise. PCA techniques have been already applied in cardiac electrophysiology, such as in the study of ventricular repolarization [11], the estimation of fibrillatory waves in AF recordings [12], ECG compression and other applications in body surface potential mapping (BSPM) among others [13], and in this paper another application concerning intracardiac recordings during AF is proposed.

2. Materials

AF intracardiac recordings were registered in 17 patients submitted to an AF ablation procedure immediately before (Table 1) and after propofol sedation (an iv bolus of 1.5–2 mg/kg, depending on weight and time to hypnosis). A 24-pole catheter (Orbiter, Bard Electrophysiology, 2-9-2 mm electrode spacing) was inserted through the femoral vein and positioned in the right atrium (RA) with the distal dipoles into the coronary sinus to record left atrial electrical activity as well. The medium and proximal electrodes were located spanning the right atrial peri-tricuspid area, from the coronary sinus ostium to the upper part of the interatrial low paraseptal region including low right septum and low left septum. Using this catheter, 12 bipolar intracardiac electrograms from the right and left atrium, were digitally recorded at 1 kHz sampling rate (16 bit A/D conversion; Polygraph Prucka Cardio-Lab, General Electric). Thirty to 60 s recordings were analyzed and compared before and during the anaesthetic effect.

Table 1
Patient clinical characteristics

Parameters	Paroxysmal AF	Persistent AF
Patients	13	4
Male (%)	9(69%)	4(100%)
Age (years)	58 ± 17	46 ± 3
Structural heart disease (%)	6(46%)	1(25%)
First AF episode		
<1 year	1	1
1–3 years	5	0
>3 years	2	3
Unknown	5	0
Prior amiodarone treatment	1	3
Prior flecainide treatment	1	1
Prior quinidine treatment	1	0
Prior propaferone treatment	2	0

3. Methods

3.1. Preprocessing process

3.1.1. Traditional filtering

The intracardiac signals are bandpass filtered using a 40–250-Hz third-order Butterworth filter. The resulting waveforms are rectified and filtered once more time using a 20-Hz low-pass third-order Butterworth filter. This filtering process enhances the periodicity or nonperiodicity of the signals. Fig. 1(b) shows an example of an electrogram filtered according to this process and its power spectral density. This algorithm was previously proposed to take a complex waveform and transform it to a series of atrial activations while diminishing the effects of changing electrogram morphology and/or amplitude [10,14].

3.1.2. Principal component analysis

In order to remove the redundancy of the electrograms and evaluate the joint trends of these signals, PCA is applied. This process is employed to emphasize the common properties of the original signals and concentrate them in a reduced set of new variables, also known as the principal components (PCs).

PCA is a popular data processing and dimension reduction technique [15]. PCA seeks the linear combinations of the original variables such that the derived variables capture maximal variance, with the restriction of being mutually orthogonal. The objective is to find a linear transformation of the original variables, ordered by high proportion of the variation of the old variables, in a set of new uncorrelated variables. Actually, each of the PCs is associated to an eigenvalue (or analogously a singular value), where the first component corresponds to the largest eigenvalue, and the following components are subsequently associated to the remaining eigenvalues in a decreasing order. In fact, the larger the ith eigenvalue, the higher variance in the original data is represented by the ith PCs.

The number of PCs to be selected can be chosen as a function of the percentage of variance in the original data to be kept. Biological expression data are currently rather noisy and redundant, and most of the information can be represented by the first few components, whereas the last components are associated