Can body position be arrhythmogenic?

Johannes L.P.M. van den Broek[1], Samaneh Heydari[1], Zhuozhao Zhan[1], Marcel van 't Veer[1], Federica Sammali[1], Sebastiaan Overeem[1], Edwin R. van den Heuvel[1], and Lukas Dekker[1]

[1]Technische Universiteit Eindhoven

November 1, 2022

Abstract

Introduction Palpitations occurring in specific body positions are often reported by patients, but the effect of body position on arrhythmia has received little research attention. We hypothesize that resting body position can exert pro-arrhythmogenic effects in various ways. For example, lateral body position is known to increase change atrial and pulmonary vein dimensions. **Methods** This observational study capitalizes on overnight polysomnography (PSG) recordings from a tertiary sleep clinic. PSGs were retrieved based on any mention of cardiac arrhythmia in the clinical report, irrespective of primary sleep diagnosis and (cardiac) comorbidities. Every instance of atrial ectopy was annotated and subgroups with a homogenous rate of atrial ectopy were created based on the Dunn index. A generalized linear mixed-effects model using age, sex, gender, sleep stage and body position was used to analyse the total amount of atrial ectopy in each combination of sleep stage and body position. Backward elimination was then performed to select the best subset of variables for the model. **Results** PSGs of 22 patients (14% female, mean age 61y) were clustered and analysed. Body position, sleep stage, age or sex did not have a significant effect on atrial ectopy in the subgroup with a low rate of atrial ectopy (N=18). However, body position did significantly affect the rate of atrial ectopy in the subgroup with a high rate of atrial ectopy (N=4; 18%). **Discussion** In each individual with a high rate of atrial ectopy, the rate of atrial ectopy was significantly higher in either left or right decubital or supine position. Increase in atrial wall stretch in lateral decubital position and obstructive respiratory events in positional sleep apnea are two possible pathophysiological mechanisms, while avoidance of a body position due to symptomatic atrial ectopy in that position is an important limitation. **Conclusion** In a selected cohort of patients with a high rate of atrial ectopy during overnight polysomnography, the occurrence of atrial ectopy is related to resting body position.

Can body position be arrhythmogenic?

Authors:

JLPM (Maarten) van den Broek*, MD[1,2], Samaneh Heydari[1], Zhuozhao Zhan, PhD[1], Marcel van 't Veer, MSc, PhD[1,2], Federica Sammali, PhD[1], Sebastiaan Overeem, MD, PhD[1,3], Edwin R. van den Heuvel, PhD[1], Lukas R. Dekker, MD, PhD[1,2]

1. Eindhoven University of Technology, The Netherlands
2. Catharina Hospital, Eindhoven, The Netherlands
3. Kempenhaeghe Centre for Sleep Medicine, Heeze, The Netherlands

Corresponding author

Maarten van den Broek

Department of Cardiology

Catharina Hospital

Michelangelolaan 2

5623 EJ Eindhoven

The Netherlands

Email: maarten.vd.broek@catharinaziekenhuis.nl

ORCID iD: 0000-0001-7888-9127

Abstract word count: 321

Manuscript word count: 1115

Number of figures/tables: 2

Data availability: The data used in this study is available upon request for non-commercial use.

Conflict of Interest: none declared

Funding: The Catharina Research Fund funded this study.

Notation of prior publication: The content of this article is not presented nor published elsewhere.

All authors contributed to the research and manuscript.

Co-author contact details

Samaneh Heydari

Department of Mathmatics

Eindhoven University of Technology

s.heydari1@tue.nl

Zhuozhao Zhan

Department of Mathmatics

Eindhoven University of Technology

z.zhan@tue.nl

Marcel van 't Veer

Catharina Hospital

Department of Cardiology

Email: marcel.vh.veer@catharinaziekenhuis.nl

Federica Sammali

Department of Electrical Engineering

Eindhoven University of Technology

f.sammali@tue.nl

Sebastiaan Overeem

Kempenhaeghe Centre for Sleep Medicine

s.overeem@kempenhaeghe.nl

Edwin van den Heuvel

Department of Mathmatics

Eindhoven University of Technology

e.r.v.d.heuvel@tue.nl

Lukas Dekker

Catharina Hospital

Department of Cardiology

Lukas.dekker@catharinaziekenhuis.nl

Key words list

atrial ectopic beat

body position

ectopic atrial tachycardia

sleep

Abbreviation list

GLMM – Generalized linear mixed-effects model

LLDP – left lateral decubital position

OSA – obstructive sleep apnea

PAC – premature atrial contraction

PSG – polysomnography

RLDP – right lateral decubital position

Abstract

Introduction Palpitations occurring in specific body positions are often reported by patients, but the effect of body position on arrhythmia has received little research attention. We hypothesize that resting body position can exert pro-arrhythmogenic effects in various ways. For example, lateral body position is known to increase change atrial and pulmonary vein dimensions.

Methods This observational study capitalizes on overnight polysomnography (PSG) recordings from a tertiary sleep clinic. PSGs were retrieved based on any mention of cardiac arrhythmia in the clinical report, irrespective of primary sleep diagnosis and (cardiac) comorbidities. Every instance of atrial ectopy was annotated and subgroups with a homogenous rate of atrial ectopy were created based on the Dunn index. A generalized linear mixed-effects model using age, sex, gender, sleep stage and body position was used to analyse the total amount of atrial ectopy in each combination of sleep stage and body position. Backward elimination was then performed to select the best subset of variables for the model.

Results PSGs of 22 patients (14% female, mean age 61y) were clustered and analysed. Body position, sleep stage, age or sex did not have a significant effect on atrial ectopy in the subgroup with a low rate of atrial ectopy (N=18). However, body position did significantly affect the rate of atrial ectopy in the subgroup with a high rate of atrial ectopy (N=4; 18%).

Discussion In each individual with a high rate of atrial ectopy, the rate of atrial ectopy was significantly higher in either left or right decubital or supine position. Increase in atrial wall stretch in lateral decubital position and obstructive respiratory events in positional sleep apnea are two possible pathophysiological mechanisms, while avoidance of a body position due to symptomatic atrial ectopy in that position is an important limitation.

Conclusion In a selected cohort of patients with a high rate of atrial ectopy during overnight polysomnography, the occurrence of atrial ectopy is related to resting body position.

Introduction

Palpitations occurring in a specific body position are often reported in the outpatient clinic. However, there is only little knowledge on the effect of different body positions on the occurrence of arrhythmia to support this clinical observation. Left and right decubital position (LLDP and RLDP) increase pulmonary vein strain [1], which can lead to premature atrial contractions (PAC)[2]. Supine position is infamous for evoking more apneas in obstructive sleep apnea (OSA) [3], which in turn is correlated with an increase in PAC's [4]. Here we assess the hypothesis that resting body position can exert atrial proarrhythmogenic effects by capitalizing on overnight sleep studies to study atrial ectopy – an umbrella term for PAC, onset of atrial tachycardia and bigeminy.

Methods

Study Cohort

This study was conducted using polysomnography (PSG) recordings from the Sleep and Obstructive Sleep Apnea Measuring with Non-Invasive Applications (SOMNIA) database [5]. PSGs for this study were selected when the associated clinical report contained any of the terms "atrial fibrillation, premature atrial contraction (PAC), atrial tachycardia or arrhythmia".

Polysomnographic Data

Body position was automatically detected using a position band. Sleep stage was annotated to the guidelines of the American Academy of Sleep Medicine [6]. ECG lead II was sampled at 512Hz and annotated post-hoc by a cardiologist (MB) for the occurrence of PAC, atrial tachycardia, atrial fibrillation and atrial bigeminy using custom software (Matlab, version R2019a; Natick MA).

Statistical analysis

Hierarchical clustering was applied to the atrial ectopy rate to create homogeneous subgroups of patients, determined by the Dunn index. An analysis of the total amount of atrial ectopy at each combination of sleep stage and body position was conducted with a negative binomial distribution using its canonical link function, conditionally on a latent variable for each patient. This demonstrated whether differences between patients were systematic. Thus, a generalized linear mixed-effects model (GLMM) determined if one body position or sleep stage was most likely to increase the risk of experiencing atrial ectopy. The model was adjusted was adjusted for age and sex. The latent variable acted as a random intercept for each patient having a normal distribution with mean zero and a variance that depends on subgroup. Likelihood ratio tests were used to perform variable selection to select the best subset of independent variables. Backward elimination removed insignificant independent variables (p-value >0.05). Lastly, patients in the subgroup with a high rate of atrial ectopy were analysed further to demonstrate in which body position atrial ectopy is more prevalent.

Results

A total of 22 PSG were identified mentioning presence of arrhythmia in the report. Patients (14% female, median age 61y [IQR 53-69y]) had a mean sleep time of 6.50 hours (SD 1.3h). The median time spent in LLDP, supine, RLDP, prone and upright position was 155, 116, 49, 3 and 0 minutes respectively. The median atrial ectopy rate was 17.5/h and consisted mostly of PAC's (16.5/h). Nine patients showed moderate or severe sleep apnea. Variable selection with a GLMM demonstrated that none of the included variables affected atrial ectopy rate in the overall group. Using the Dunn index, two groups were identified (index 5.555). Subgroup 1 (4/22) with high rate of atrial ectopy and subgroup 2 (18/22) with a low rate of ectopy. Sex, apnea-hypopnea index, age, body position and sleep stage did not significantly differ between the subgroups. Subgroup 2 was not analysed further due to the low atrial ectopy rate.

Figure 1 shows the time spent per body position (blue bars) and amount of atrial ectopy per body position (red bars) as a percentage of total time per patient in subgroup 1. The four patients had 1,050, 805, 1,099 and 1,050 instances of atrial ectopy, respectively. Variable selection with a GLMM demonstrated that body position (P =0.032) significantly affected the amount of atrial ectopy, while age (P =0.936), sex (P =0.967), and sleep stage (P =0.754) did not. The likelihood ratio test per patient was 105.19, 214.09, 856.95 and 44.82, respectively (all P <0.001, Bonferroni), demonstrating a significant difference between the amount of atrial ectopy per body position in every patient. RLDP, LLDP and supine position had significantly more atrial ectopy than prone and upright position (Table 1), with specific body positions per patient being most proarrhythmogenic. In patients 1 and 2, atrial ectopy rate was higher in both RLDP and LLDP, compared to supine and upright (patient 1) or prone (patient 2) position (p-values in Table 1). In patient 3, atrial ectopy rate was highest in, followed by the supine position, compared to RLDP (p-values in Table 1). In patient 4 atrial ectopy rate was highest in RLDP compared to both LLDP and supine position (p-value in Table 1).

Discussion

Using overnight PSG, we showed that the occurrence of atrial ectopy is dependent on body position in patients with a high rate of atrial ectopy.

Two pathophysiological mechanisms potentially explain the arrhythmogenicity of body position. First, changes in atrial wall strain constitute a proarrhythmogenic substrate by an overall decrease in conduction velocity, increased incidence of slow conduction sites and local conduction blocks [7]. An MRI study demonstrated higher flow and vessel area in the veins of the lowermost lung in lateral decubital position [8]. In another, especially LLDP increased strain in the pulmonary veins [1]. This mechanism could explain the results in patient 1, 2 and 4; in these patients LLDP or RLDP had a significantly higher rate of atrial ectopy (Table 1).

Second, in patients with OSA, breathing events occur more often in the supine position [3]. Apneas can exert various arrhythmogenic effects through intrathoracic pressure shifts, changes in blood gasses and sympathovagal imbalance [9]. In patient 3 this could be relevant as 98% of atrial ectopy and 97% (112/115) of apneas occurred in supine position, resulting in a supine apnea-hypopnea index 22.4/h.

Limitations

Symptomatic positional atrial ectopy could cause patients to change or avoid body positions. The arrhythmogenic effects of that body position would then not be observed in this study. Patient 2 and 3 both had a high event rate in RLDP and LLDP, respectively, and both spent very little time in these respective positions (Figure 1). Based on the retrospective nature of the study and unbeknownst to these patients' symptoms, this hypothesis could not be tested here, but could be subject of future studies.

Despite the relatively low number of subjects, the long recording times provided by assessing PSG data provide relevant evidence that body position during sleep has an effect on atrial ectopy rate in patients with high rates of atrial ectopy. Further research is warranted to explore the broader prevalence and pathophysiological background of this observation.

Conclusion

In patients with a high atrial ectopy rate, the occurrence of atrial ectopy during overnight polysomnography is related to body position.

References

1. Gottlieb LA, El Hamrani D, Naulin J, et al. A left lateral body position increases pulmonary vein stress in healthy humans.*Physiol Rep* . 2021;9(18):e15022. doi:https://doi.org/10.14814/phy2.15022

2. Nazir SA, Lab MJ. Mechanoelectric feedback in the atrium of the isolated guinea-pig heart. *Cardiovasc Res* . 1996;32(1):112-119. doi:10.1016/0008-6363(96)00077-6

3. George CF, Millar TW, Kryger MH. Sleep apnea and body position during sleep. *Sleep* . 1988;11(1):90-99. doi:10.1093/sleep/11.1.90

4. May AM, Van Wagoner DR, Mehra R. OSA and Cardiac Arrhythmogenesis. *Chest* . 2016;151(1):225-241. doi:10.1016/j.chest.2016.09.014

5. Van Gilst MM, Van DIjk JP, Krijn R, et al. Protocol of the SOMNIA project: An observational study to create a neurophysiological database for advanced clinical sleep monitoring. *BMJ Open* . 2019;9(11). doi:10.1136/bmjopen-2019-030996

6. Berry RB, Budhiraja R, Gottlieb DJ, et al. Rules for scoring respiratory events in sleep: update of the 2007 AASM Manual for the Scoring of Sleep and Associated Events. Deliberations of the Sleep Apnea Definitions Task Force of the American Academy of Sleep Medicine. *J Clin sleep Med JCSM Off Publ Am Acad Sleep Med* . 2012;8(5):597-619. doi:10.5664/jcsm.2172

7. Ravelli F, Masè M, Del Greco M, Marini M, Disertori M. Acute atrial dilatation slows conduction and increases AF vulnerability in the human atrium. *J Cardiovasc Electrophysiol* . 2011;22(4):394-401. doi:10.1111/j.1540-8167.2010.01939.x

8. Wieslander B, Ramos JG, Ax M, Petersson J, Ugander M. Supine, prone, right and left gravitational effects on human pulmonary circulation. *J Cardiovasc Magn Reson* . 2019;21(1):1-15. doi:10.1186/s12968-019-0577-9

9. Hohl M, Linz B, Bohm M, Linz D. Obstructive Sleep Apnea and Atrial Arrhythmogenesis. *Curr Cardiol Rev* . 2014;10(4):362-368. doi:10.2174/1573403x1004140707125137

Figure and table

Figure 1: Percentage of time spent (blue bars) and atrial ectopy (red bars) in each body position per patient. RLDP right lateral body position, LLDP left lateral body position.

[CHART][CHART][CHART][CHART]

Table 1: the relative rate of atrial ectopy (95% CI) between two body positions in subgroup 1. Bold indicates significant P -values. RLDP right lateral body position, LLDP left lateral body position, inf infinite.

	Relative rate (95% CI)	P-value
All patients		
RLDP Vs. Supine	0.95 [0.55, 1.65]	0.848
RLDP Vs. LLDP	0.63 [0.55, 1.65]	0.117
RLDP Vs. Prone	**2.36 [1.17, 4.81]**	**0.016**
RLDP Vs. Upright	**11.25 [1.79, 71.52]**	**0.010**
Supine Vs. LLDP	0.67 [0.39, 1.14]	0.140
Supine Vs. Prone	**2.51 [1.27, 4.90]**	**0.007**
Supine Vs. Upright	**11.94 [1.90, 74.44]**	**0.008**
LLDP Vs. Prone	**3.74 [1.88, 7.54]**	**0.002**
LLDP Vs. Upright	**17.81 [2.83, 112.17]**	**0.002**
Prone Vs. Upright	4.76 [0.72, 31.19]	0.104
Patient 1		
RLDP Vs. Supine	2.75 [1.70, 4.47]	**0.003**
RLDP Vs. LLDP	1.09 [0.73, 1.64]	0.573
RLDP Vs. Prone	28395 [0, Inf]	0.977
RLDP Vs. Upright	7.75 [2.02, 29.63]	**0.011**
Supine Vs. LLDP	0.39 [0.29, 0.53]	**<0.001**
Supine Vs. Prone	10309.28 [0, Inf]	0.979
Supine Vs. Upright	2.81 [0.75,10.61]	0.101
LLDP Vs. Prone	25853.47 [0, Inf]	0.977

	Relative rate (95% CI)	*P*-value
LLDP Vs. Upright	7.05 [1.92, 25.87]	**0.011**
Prone Vs. Upright	0 [0, Inf]	0.982
Patient 2		
RLDP Vs. Supine	2.69 [1.88, 3.85]	**<0.001**
RLDP Vs. LLDP	0.86 [0.63, 1.16]	0.300
RLDP Vs. Prone	3.31 [2.37, 4.63]	**<0.001**
RLDP Vs. Upright	22114.75 [0, Inf]	0.977
Supine Vs. LLDP	0.32 [0.24, 0.41]	**<0.001**
Supine Vs. Prone	1.23 [0.93, 1.62]	0.123
Supine Vs. Upright	8229.66 [0, Inf]	0.979
LLDP Vs. Prone	3.85 [3.07,4.85]	**<0.001**
LLDP Vs. Upright	25768.29 [0, Inf]	0.977
Prone Vs. Upright	6676.84 [0, Inf]	0.980
Patient 3		
RLDP Vs. Supine	0.02 [0.01,0.04]	**<0.001**
RLDP Vs. LLDP	0.01 [0.003, 0.02]	**<0.001**
RLDP Vs. Prone	347458.30 [0, Inf]	0.974
Supine Vs. LLDP	0.42 [0.21, 0.85]	**0.021**
Supine Vs. Prone	149751.09 [0, Inf]	0.967
LLDP Vs. Prone	355020.15 [0, Inf]	0.965
Patient 4		
RLDP Vs. Supine	1.62 [1.35, 1.93]	**<0.001**
RLDP Vs. LLDP	1.42 [1.19, 1.70]	**0.002**
Supine Vs. LLDP	0.88 [0.73, 1.06]	0.156