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Validating algorithms for continuous blood pressure measurement in patients with sleep apnoea

Submission date
26/04/2019

Recruitment status
No longer recruiting

Registration date
04/06/2019

Overall study status
Completed

Last Edited
29/05/2019

Condition category
Nervous System Diseases

[ ] Prospectively registered
[ ] Protocol
[ ] Statistical analysis plan
[ ] Results
[ ] Individual participant data
[ ] Record updated in last year

Plain English summary of protocol

Background and study aims
Sleep apnea is a highly prevalent sleep-related breathing disorder that affects about 10% of middle-aged adults. It is estimated that up to 90% of sleep apnea sufferers remain undiagnosed and untreated (Behar et al., 2013).

Currently, patients who are evaluated for sleep-disordered breathing at the sleep lab of UZ Leuven are hospitalised for one night during which a full-night polysomnography (PSG) is recorded. After this recording, the acquired signals are analysed by sleep experts and checked for anomalies. Even though this procedure is the gold standard in sleep medicine, it is only performed during one night and it is often associated with low comfort and high costs. Furthermore, the capacity of sleep centres is generally limited, which results in long waiting lists. At this point, for instance, a procedure to prioritize patients would improve the diagnosis and treatment of sleep apnea. Currently, the apnea/hypopnea index (AHI), which is a parameter derived from the PSG, is used to assess the severity of obstructive sleep apnea (OSA). The aim is to have an estimation of the AHI during waking hours and identification of severe sleep apnea patients using an unobtrusive system which can be executed in a home-based setting. The advantage of detection during waking hours is that the exclusion of many confounding factors during sleep. The autonomic nervous system has complex behaviour during sleep. Its activity is variating as the body cycles through REM and non-REM sleep phases. Performing the experiment during waking hours, the extra challenge of sleep classification through wearable sensors in patients with potentially suffering from sleep apnea is put aside.

Furthermore, individuals suffering from moderate to severe apnea experience an elevation in sympathetic activity of the nervous system. This elevation is a key contributor to hypertension (Rossi et al., 2013), which can lead to cardiovascular and cerebrovascular diseases without proper follow-up. Invasive blood pressure (BP) measurement exhibits the highest accuracy, though involves training and risks. This method is generally applied in intensive care units. Non-invasive measurement systems such as a mercury sphygmanometer or oscillometric blood pressure devices are highly accurate as well. However, these do not provide continuous BP measurement nor are they suitable for home-based measurement (Wang et al., 2018). The

second aim of this study is to develop a wearable and continuous BP measurement device in order to identify and follow-up a hypertensive population.

Who can participate?
Participants are patients referred to the sleep lab for a diagnostic polysomnography because of suspicion of sleep apnea will be considered to participate in the trial upon signature of the informed consent. Participants should be 18 years or older, have a body mass index below 55 kg /m2 and should not suffer from atrial fibrillation.

What does the study involve?
1. The patient is presented with an informed consent form (ICF)
2. Included patients are attached to the PSG PPG and ECG sensors before BP measurements. PPG is attached to the middle finger of the non-dominant hand.
2.1. Adhesive patches containing reflective PPG sensors are used. The patches are attached to the patient's wrist and upper arm on the side of the non-dominant hand. The upper arm sensor is placed high enough such that BP measurement can be taken below the sensor.
2.2. An adhesive patch containing an ECG sensor is attached to the patient's chest.
2.3. A fingerclip PPG sensor is put on the patient's index finger of the non-dominant hand.
3. A BP measure is taken twice with the patient under resting conditions and after the patient was allowed to rest for at least 5 minutes. There is at least a 10-minute interval between BP measurements. All measurements are performed before the patients go to sleep.

What are the possible benefits and risks of participating?
The study is carried out within clinical routine and corresponding procedures. Since the custom measuring system with sensors is completely non-invasive, no adverse reactions are expected and there is no additional risk expected to the patient, nor to the investigator. No benefits are present for the participant apart from providing aid in clinical research for continuous blood pressure measurements and simplified sleep apnea screening.

Where is the study run from?
The study is run in the Sleeplab of UZ Leuven, Leuven, Belgium.

When is the study starting and how long is it expected to run for?
The study itself starts 15/04/2019 and is expected to run for a maximum of 6 months.

Who is funding the study?
The study is funded by Verhaert and KU Leuven under the eWatch project.

Who is the main contact?
The main contact is Dorien Huysmans (dorien.huysmans@esat.kuleuven.be).
The principal investigator is Dries Testelmans (Herestraat 49, 3000 Leuven).

Contact information

Type(s)
Public

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Additional identifiers

Protocol serial number
S62173

Study information

Scientific Title
Blood pressure derivation from short term raw PPG signals measured by a wearable device.

Acronym
N/A

Study objectives
The purpose of this study is the validation of algorithms for continuous blood pressure measurement. The overall goal is the development of algorithms based on the analysis of wearable PPG data for fast and cheap assessment of BP in patients suffering from sleep apnoea.

Ethics approval required
Old ethics approval format

Ethics approval(s)
Approved 18/01/2019, Ethical Commission Research UZ/KU Leuven (Herestraat 19, 3000 Leuven, Belgium; ec@uzleuven.be; 016 34 86 00), ref: B322201938732.

Study design
Single-centre observational cross-sectional cohort study

Primary study design
Observational

Study type(s)
Other

Health condition(s) or problem(s) studied
Sleep apnoea

Interventions
The algorithms will be first developed using an online database, i.e. Medical Information Mart for Intensive Care II (MIMIC II), which contains BP measurements using intra-arterial blood pressure,

ECG and PPG. Then, the algorithms will be validated using the PPG and ECG data collected in the UZ Leuven sleep lab together with measurements of BP using the cuff.

Included patients are attached to the PSG PPG and ECG sensors before BP measurements. PPG is attached to the middle finger of the non-dominant hand.
1. Adhesive patches containing reflective PPG sensors are used. The patches are attached to the patient's wrist and upper arm on the side of the non-dominant hand. The upper arm sensor is placed high enough such that BP measurement can be taken below the sensor.
2. An adhesive patch containing an ECG sensor is attached to the patient's chest.
3. A fingerclip PPG sensor is put on the patient's index finger of the non-dominant hand.

After connection of all sensors (PSG + wearable), the synchronisation button of the PSG is pressed. This action supports the synchronisation of the wearable sensors with the PSG.

A BP measure is taken twice with the patient under resting conditions and after the patient was allowed to rest for at least 5 minutes. There is at least a 10-minute interval between BP measurements. All measurements are performed before the patients go to sleep. The synchronisation button of the PSG is pressed during every BP measurement. The BP measurement is taken on the arm of the dominant hand.

Intervention Type
Device

Phase
Not Applicable

Primary outcome(s)
The accuracy of blood pressure values estimated from wearable PPG is compared against values obtained using a blood pressure cuff at baseline during wake hours. The error (mean and standard deviation) between the estimated systolic BP/diastolic BP and the cuff value will be calculated. A T-test will evaluate significant differences. Bland-Altman analysis will be used to check the interchangeability of the two methods.

Key secondary outcome(s)
Parameters derived from polysomnography and wearable data during waking hours at baseline will be evaluated to differentiate patients with severe sleep apnea (AHI >= 30) from patients with milder or no sleep apnea (AHI < 30). In order to determine the best parameters that can differentiate patients with different AHI, two groups of patients will be created using the dataset collected for the first goal. One group will contain only patients with AHI < 30 and the other group will contain matched subjects suffering from patients with AHI ≥ 30. Patients will be matched one-by-one using age, gender and BMI. This information is contained in the 'LUCS: Vragenlijst' questionnaire. For each computed parameter, the differences between the groups will be tested using the Wilcoxon test. In addition, apart from looking at significant levels (α=0. 05), different classifiers based on linear discriminant analysis, Support Vector Machines (SVM), and Least-Squares SVM will be implemented for the separation of apnea patients with high and low AHI. Finally, the accuracy of the separation will be also analyzed using the F1 score.

Completion date
15/04/2020

Eligibility

Key inclusion criteria
Referred to the sleep lab for diagnostic polysomnography because of suspicion of sleep apnoea.

Participant type(s)
Patient

Healthy volunteers allowed
No

Age group
Adult

Sex
Female

Key exclusion criteria
1. Younger than 18 years.
2. Body Mass Index > 40 kg/m2.
3. Diagnosed with atrial fibrillation.
4. Have a pacemaker.
5. Dark skin tone.

Date of first enrolment
15/04/2019

Date of final enrolment
15/10/2019

Locations

Countries of recruitment
Belgium

Study participating centre
Multidisciplinair centrum voor slaapmonitoring (slaaplabo) of UZ Leuven
UZ Leuven, Herestraat 49, 3000 Leuven.
Leuven
Belgium
3000

Sponsor information

Organisation
Agentschap Innoveren en Ondernemen

ROR
https://ror.org/032xdry56

Funder(s)

Funder type
Government

Funder Name
Agentschap Innoveren en Ondernemen

Alternative Name(s)
Flanders Innovation and Entrepreneurship, AGENCY FOR INNOVATION & ENTREPRENEURSHIP, VLAIO

Funding Body Type
Government organisation

Funding Body Subtype
National government

Location
Belgium

Results and Publications

Individual participant data (IPD) sharing plan
All information collected during the study will be stored on a computer of the UZ Leuven. The identity of the patient will be replaced by an identification code. Only the data administrators (Prof. B. Buyse en Prof. D. Testelmans, Slaaplabo/Pneumologie, UZ Leuven) will know this data is related to the patient. Only the coded data will be transferred to the administrator of the data server of the sponsor (Koen Van Bossche, Verhaert, Hogenakkerhoekstraat 21, 9150 Kruibeke).

IPD sharing plan summary
Not expected to be made available