FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG
FACULTY OF MEDICINE

Universitätsklinikum Erlangen

New insights into the dying phase provided by radar-based biometric assessment

Steigleder T.[1], Malessa A. [1], Shi K. [2], Schellenberger S. [3], Heckel M.[1], Kölpin A. [3], Ostgathe C. [1]

[1] Department of Palliative Care, Universitätsklinikum Erlangen, Erlangen, Germany
[2] Institute for Electronics Engineering, Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany
[3] Institute of High-Frequency Technology, Hamburg University of Technology, Germany

Background

Pathophysiological changes of the dying phase in non-invasive setting are hardly known, but can enable health care practitioners to predict dying and adjust care accordingly. Touchless means of assessing biomarkers can allow for non-invasive monitoring. We researched radar-based monitoring (RBM) to detect vital parameters and present first findings of pathophysiological changes of dying in a non-invasive setting of a palliative care (PC) ward.

Aim

We aim at identifying changes in heart rate (HR), heart rate variability (HRV), heart sounds (HS) and breathing (BR), which point to dying and can be assessed by RBM as a groundwork for research into algorithms to predict death and dying in severely ill patients.

Methods

After giving consent patients were monitored on our PC ward until death. Four bioradars (24GHz interferometric radar-systems) were placed beneath the mattress (fig. 1) and recorded changes of distance (DC) to the nearest impenetrable object, i.e. the patient's skin with a precision of 10^10 nm in microseconds. Learning algorithms used the data on distance to assess pulse wave (PW), HS and BR. Changes were correlated with clinical observations of dying.

Figure 1

Showing placement of the radar system beneath a mattress; radar properties are optimized for penetration of mattress as well as average distance to the patient. As radar waves permeate any barrier, which is less dense than water, clothing, bedding, mattresses, wooden panels will not decrease radar performance.

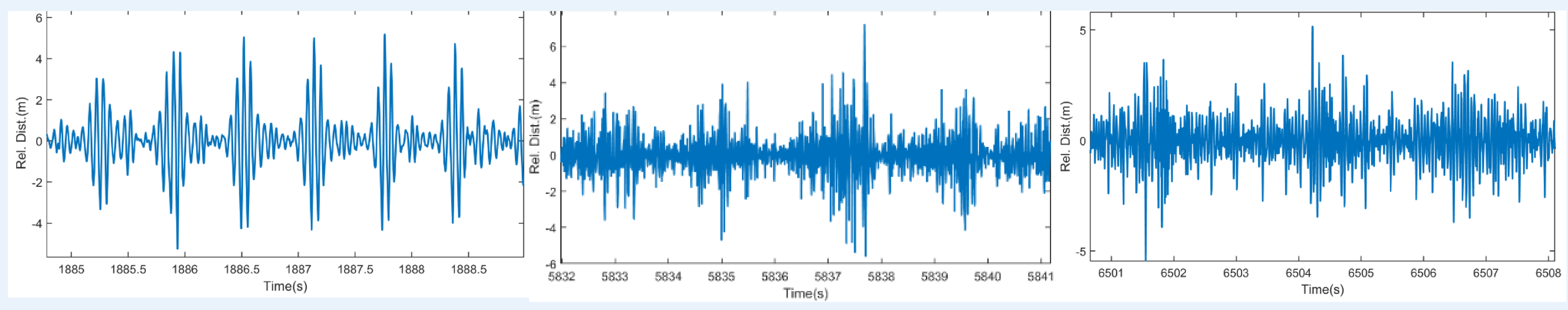
Results

n=4 patients died in October 2019 monitored by bioradar. We observed changes, which heralded dying:

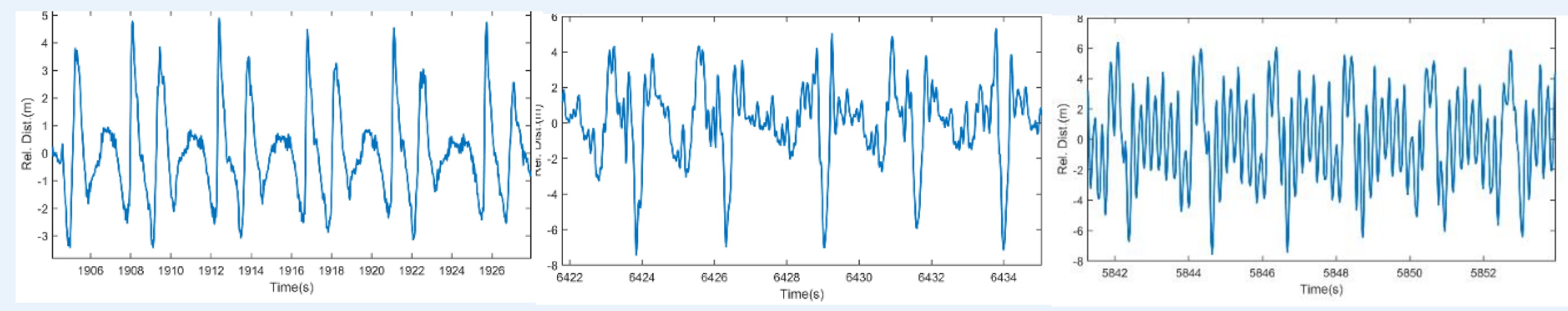
In three days before death:

- Reduction in segmentation of HS (fig. 2a)
- Change of configuration of PW (fig. 2b)

Figure 2 *Each row of three graphs show HS and PW, respectively, 24hrs, 12 hrs, and 30min before death occurred; patient ID 1001*



2a depicts HS as recorded by RBM; segmentation of HS in first HS, hiatus, second HS, hiatus is clearly visible in the first graph as well as a continuous degradation of HS over time



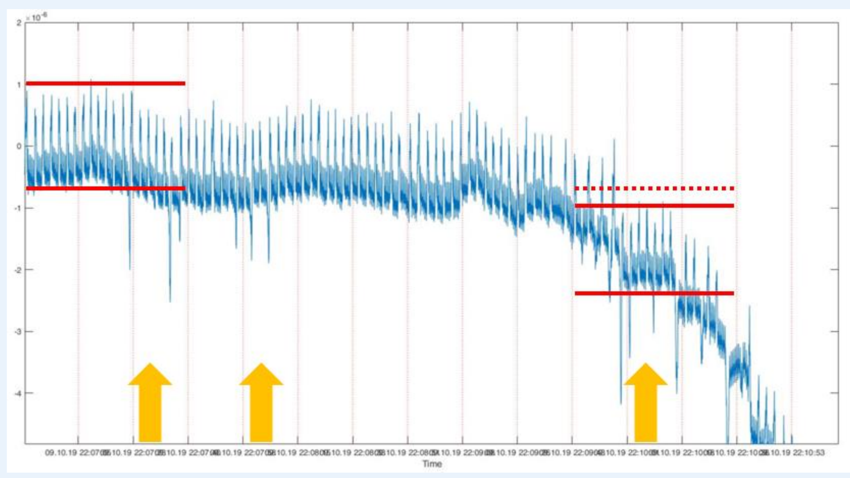
2b depicts PW as recorded by RBM; PW showing the dichrotic notch is clearly visible in the left graph as well as its change over time

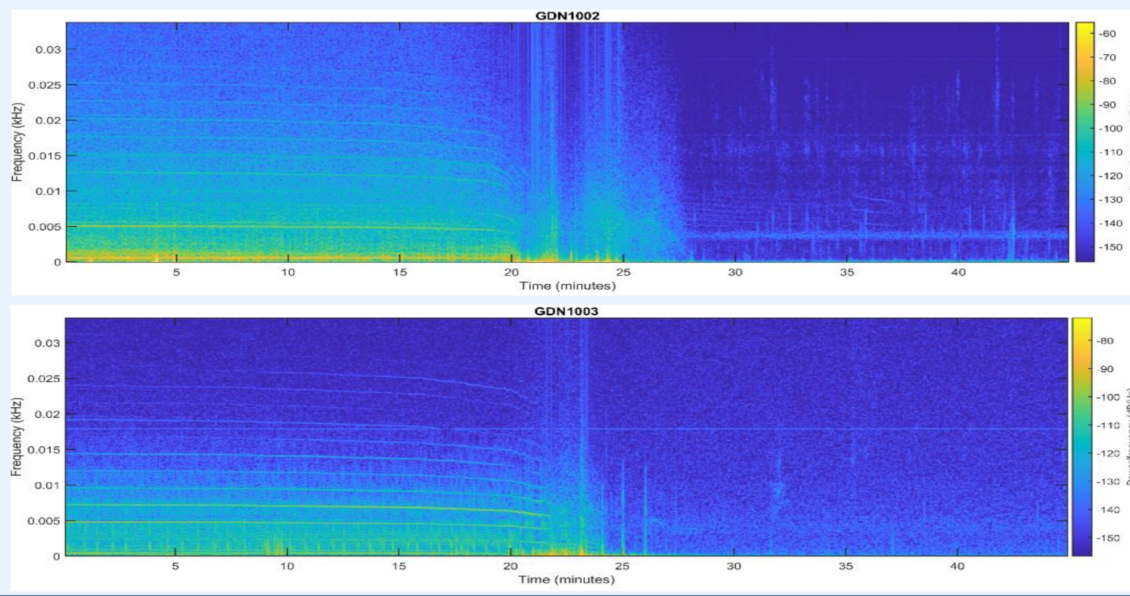
In the dying phase:

- Erratic bursts of BR (fig. 3a)
- Decrescendo pattern of PW (fig. 3a)
- Change of frequency bands of DC (fig. 3b)

Figure 3

3a shows PW and BR in 3 minutes before death occurred; red bars indicate a reduction in amplitude of PWs; golden arrows indicate erratic bursts of shallow breathing

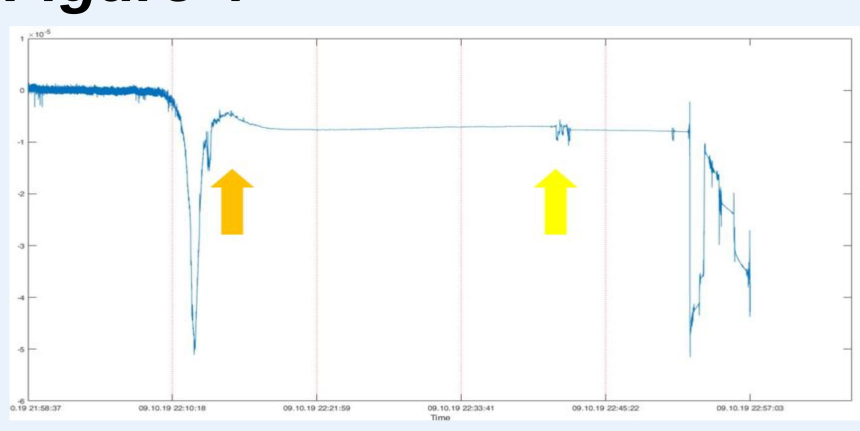




3b depicts frequency bands before and after death (time of death indicated by red bar); a specific change in frequency bands occurred with death and can be used for an automated detection

We found, that RBM can detect dying in a timely and automated fashion (fig. 4)

Figure 4



Depicted is change of distance by RBM in the dying phase; as recorded by RBM death occurred at 22:12 o'clock (golden arrow); RBM was displayed life, but evaluated post hoc; in the clinical setting patient was found and time of death pronounced at 22:41 (yellow arrow)

Conclusion

RBM can provide information on impending and occurring dying phase and thereby both improve PC by supporting decision on allocating resources and help in starting life support and/or cardio-pulmonal reanimation in a timely fashion in non-PC settings.

www.palliativmedizin.uk-erlangen.de

✉ tobias.steigleder@uk-erlangen.de