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Towards prediction of the incidence of acute aortic dissection type A

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1. Introduction

Acute aortic dissection (AAD) is the third main driver of the out-of-hospital immediate death (Manfredini et al., 2008). Despite the state-of-the-art therapeutic and diagnostic methods, AAD develops hastily with often fatal consequences. Although the AAD was first reported more than two centuries ago there is still less knowledge about the origins and causes of it (Hagan et al., 2000). Environmental factors may influence the onset of cardiovascular incidents like acute myocardial infraction, rupture of intracranial aneurysm or abdominal aorta (Benouaich et al., 2010). Using a dataset of n=464 patients' history, Hagan et al., 2000 showed that the mortality of type A AAD (n=289) was about 26% for those who received surgery and 58% who did not receive surgery. Previous studies indicate that the incidence of AAD follows a non-random behavior (Benouaich et al., 2010; Mehta et al., 2002;Manfredini et al., 2013; Verberkmoes et al., 2012; Sumiyoshi et al., 2002; Mehta et al., 2005). Many studies referred to the existence of a chronobiological behavior in the occurrence of AAD. Winter and Autumn months present a higher risk of occurrence of AAD (Talbot and Langman, 1972; Castelden and Mercer, 1985; Liapis et al., 1992; Kobza et al., 2002; McCarthy et al., 2003; Harkin et al., 2005; Manfredini et al., 2008; Benouaich et al., 2010). The existence of chronobiological variations in AAD leads to the question whether there is a linkage between weather or climatic conditions and the incidence of AAD and to what extend it could be predicted?

The linkage between the onset of cardiovascular and cerebrovascular diseases in different countries has been investigated in several studies. However, the results are controversial (Dilaveris et al., 2006). Up to now very few studies investigated the bioclimatic origins of the AAD (eg. Benouaich et al., 2010; Verberkmoes et al., 2012; Ishikawa et al., 2012). According to Bennouaich et al., 2010, the cold weather and temperature decrease may play a major role in frequency of AAD incidence. They investigated the medical reports of 206 patients who received surgery for type A AAD in Toulouse University hospital during 1997 to 2007. However, they proposed further investigations of such correlations. Using a data set of n=11.412 patients during the January 1998 to February 2010, Verberkmoes et al., 2012, found that a higher risk of AAD occurs in cold weathers. The study of Ishikawa et al., 2012, was the unique study that investigated a combination of several detailed meteorological parameters and vascular diseases. Previous studies mostly focused on the relation between a single climatic parameter and the particular disease.

The weather is a chaotic system whose evolution is hard to predict (predictions of up to ten days are possible). The atmosphere is influenced by its interaction with ocean, land and ice which response to the solar heating. The interaction and feedback processes between different components of the climate system are still not fully known. With rising greenhouse gases concentration after the industrial revolution, the physical-chemical-biological conditions present extreme chaotic behavior. Here, we propose using a new methodology, which considers the different weather phases instead of single or several meteorological variables. To our knowledge, all previous studies utilized the meteorological variables in a single atmospheric level (e.g. surface level) and in a single or several meteorological stations located close to the target Hospital. The teleconnection and the feedback processes between the different atmospheric layers and their spatial patterns are invisible to such approaches. The weather phases are characterized by different dynamical weather processes. By clustering the weather conditions into different phases, we consider the relation between different meteorological variables in both time and space. The main focus of this study is to answer the question whether there is a relationship between different weather phases and the incidence of type A AAD in Berlin area.

2. Data and Methods

The Tölzer Weather Classification (TWC) (Brezowsky, 1965), which is named after the medicine-meteorological research center in Bad Tölz, is applied to cluster the bio-meteorological conditions based on several climatic variables (e.g. temperature, pressure, wind). This scheme deals with the passage of high and low level systems which form warm and cold fronts. Each weather phase contains specific meteorological characteristics like pressure gradient, temperature advection, wind, cloudiness and precipitation. This originates from the differences in the dynamical processes behind each weather phenomenon. Considering the passage of an idealized cyclone, it contains six different idealized periodic phases (Table 1). After Brezowsky, 1965, the weather phases 4, 5 and 6 are also divided to sub-phases (Table 2).

Table 1: Weather phases and their characteristics.

Weather phases	Characteristics
1	Mean fair weather
2	Increasing fair weather
3	Exaggerated Föhn fair weather
4	upcoming weather changes
5	mature weather changes
6	settled weather

Table 2: Weather sub-phases and their characteristics.

Weather sub-phases	Characteristics
4.1	stable sliding warm front
4.2	unstable sliding warm front
4.3	warm front passage
5.1	stable sliding cold front
5.2	occluded front passage
6.1	cold front passage
6.2	upcoming high-pressure instability

To investigate the weather-AAAD incidence relation, the weather types are defined using the TWC during the period 2006 to 2013 over the Berlin/Brandenburg Metropolitan Region (BBMR) . AAAD onset data were obtained from the German Heart Center in Berlin based on the in-hospital questionnaire for the period 2006 to 2013. The data includes the information on the pain incidence hour, history and outcome of patients from BBMR.

3. Results

The incidence time of the chest pain of the patients with AAAD diagnosis was noted as the symptom onset. In 497 patients the precise time of the symptom onset was available. Figure 1 shows the normalized histogram of seasonal, weekly and daily onsets of AAAD cases during 2006 to 2013 in area Berlin. There is a clear bimodality in the seasonal cycle with larger peak during the Autumn (Fig.1.a). The other peak occurs early Spring and late Winter. Mehta, et al., 2002, showed that the occurrence of AAAD peaks during December which does not reject the null hypothesis at 95% confidence level (p-value= 0.308). They considered a sinusoidal function to fit the monthly data which contains one peak. The weekly variation of AAAD presents a peak on Mondays (Fig.1.b). The daily cycle of AAAD incidence reaches the maximum at noon (Fig.1.c).

We have also used Superposed Epoch Analysis (SEA) method (Adams et al. 2003) to detect the response (if existed) of meteorological variables (Relative Humidity and Surface Temperature) to the onset of AAD. The SEA method sorts the data into categories with respect to the 'key-events' (AAD onset). Here we have used hourly observed meteorological data from the station Tegel in Berlin. The statistical significance is derived from Monte Carlo block re-sampling with n = 10,000 iterations. The relative humidity (Fig. 2) shows a significant maximum at 11 hours before the onset of AAD. The surface temperature (Fig.3) also indicates a significant minimum at lag = -9 hours with a rebound into the positive values (at lag=+2 hours).

Using the Tölzer classification we clustered the weather conditions into different classes for the period 2006-2013 based on 6 hourly meteorological data. Figure 4 shows the frequency of different classes for this period.

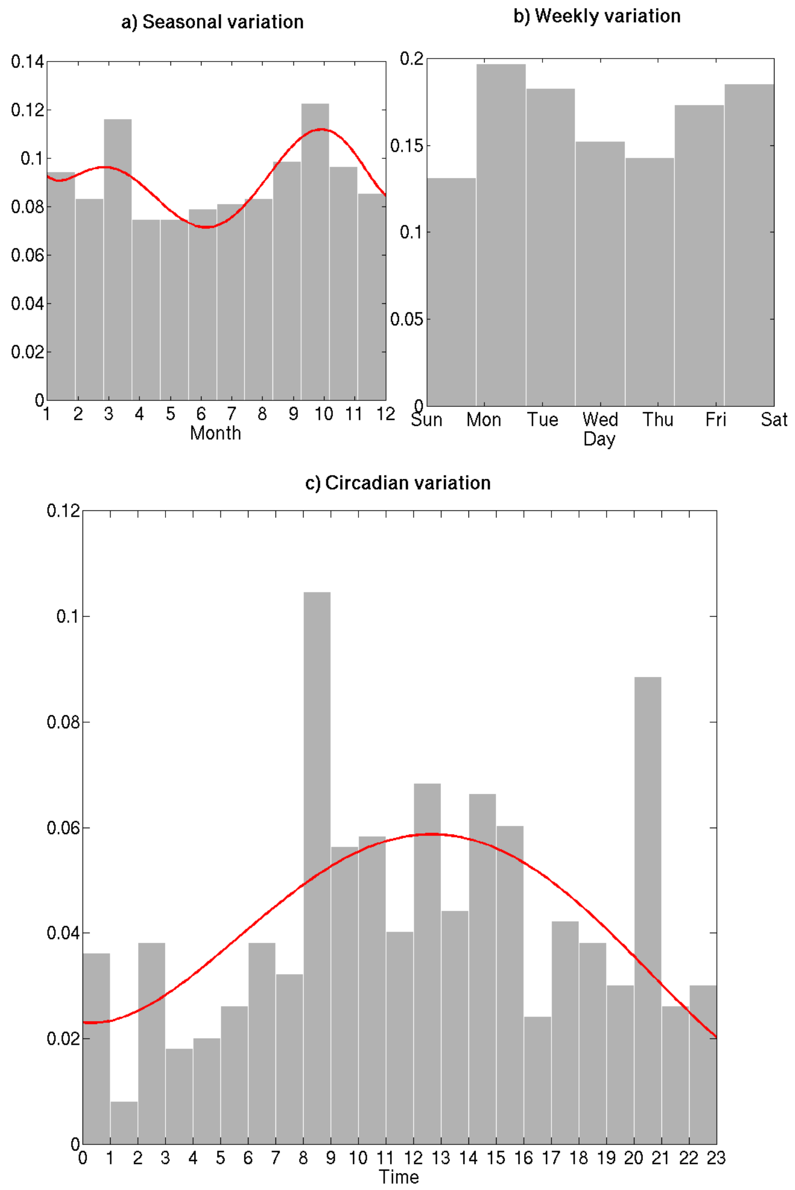

Fig. 1 Normalised frequency of AAAD onset for Berlin during the period 2006-2013 for (a) different seasons, (b) different days and (c) daily cycle. Red lines in (a) and (c) indicate the normalised PDFs.

The frequency of different Tölzer phases over Berlin reveal that for this area the most probable phases are the phase 1 and 2, resembeling the mean fair weather and increasing fair weather, respectively. In the last step, we calculated the frequency of weather phases conditioned on the incidence of AAAD events in Berlin (not shown). The results show that during the AAAD events, phase 4.3 and 5.1 are significantly the most probable cases. These two phases indicate the upcoming change in the weather pattern and change in the weather pattern, respectively.

4. Discussion

The methods presented in this study, presents a primarily study about the understanding of the possible weather-related mechanisms which influence the AAAD onset. This paper aims to suggest a method towards designing an early warning system to give probability estimate of the AAAD onset with respect to prediction of different weather phases. The results show that most of the AAAD are coincident with changes in the weather patterns and meteorological parameters over the region Berlin with a relation to seasons of the year. We note that the subjective TWC method is a time-consuming approach which does not fit the concept of early warning system. In the future effort, we aim to design an automatic bio-meteorological pattern detection system which is coupled with a weather forecast model and delivers operational predictions of AAAD onset based on weather conditions. With existence of dramatic climate change, such an early warning system can be applied to study the possible pathways of the probability of AAAD onset under different Green House Gas (GHG) concentration scenarios.

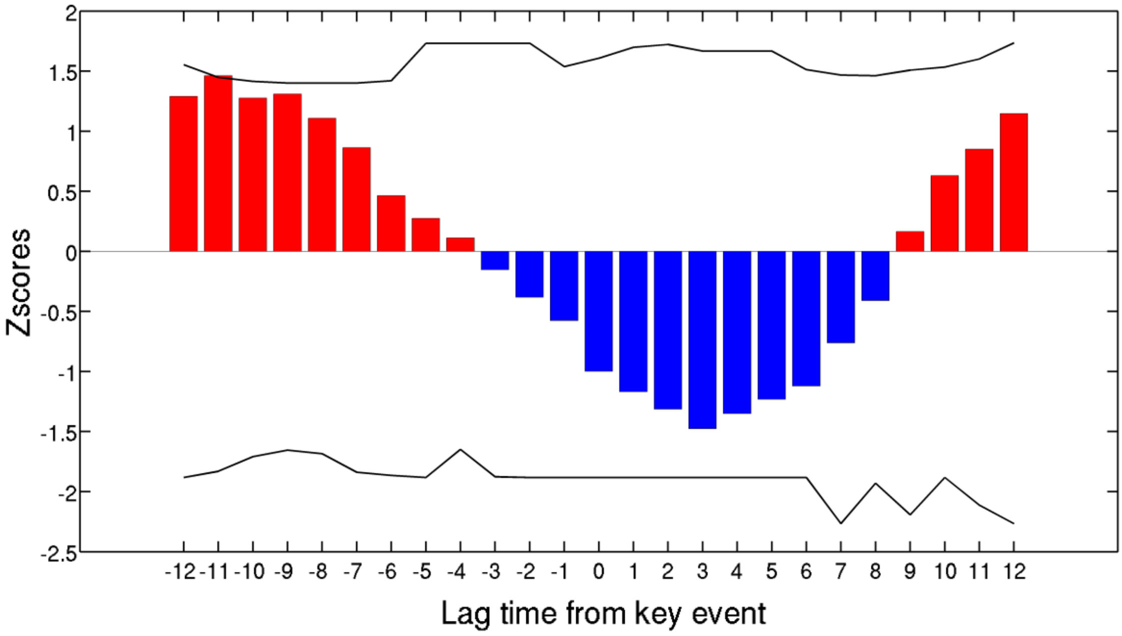

Fig. 2 Superposed epoch analysis using the hourly relative humidity of station Tegel in Berlin and AAD onset. Significance levels (99%) are shown by horizontal lines.

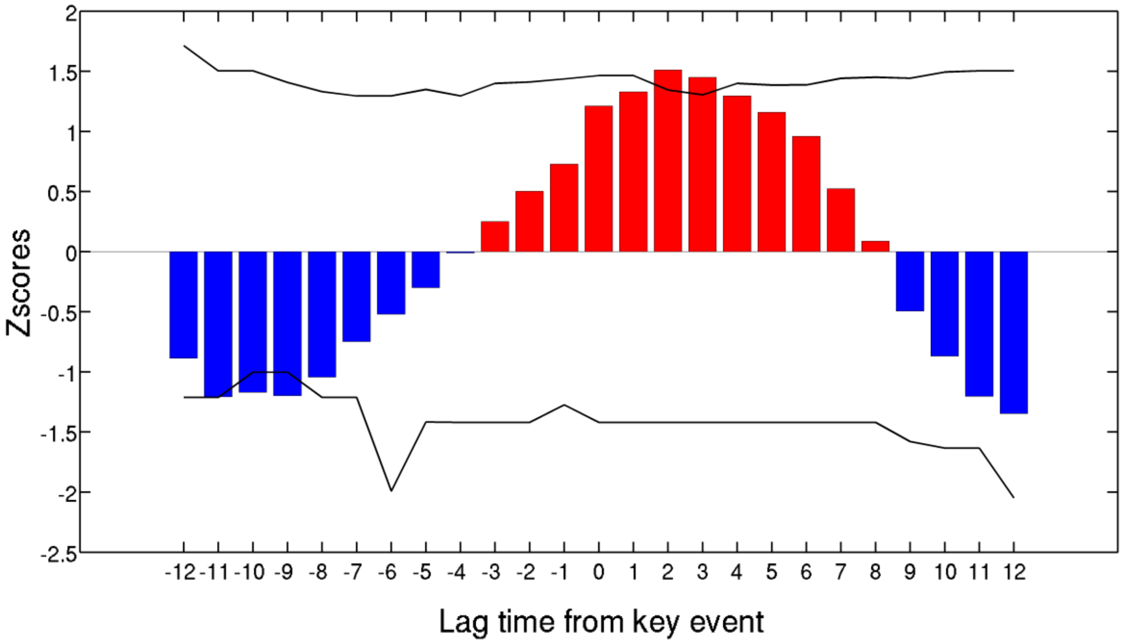

Fig. 3 Superposed epoch analysis using the hourly surface temperature of station Tegel in Berlin and AAD onset. Significance levels (99%) are shown by horizontal lines.

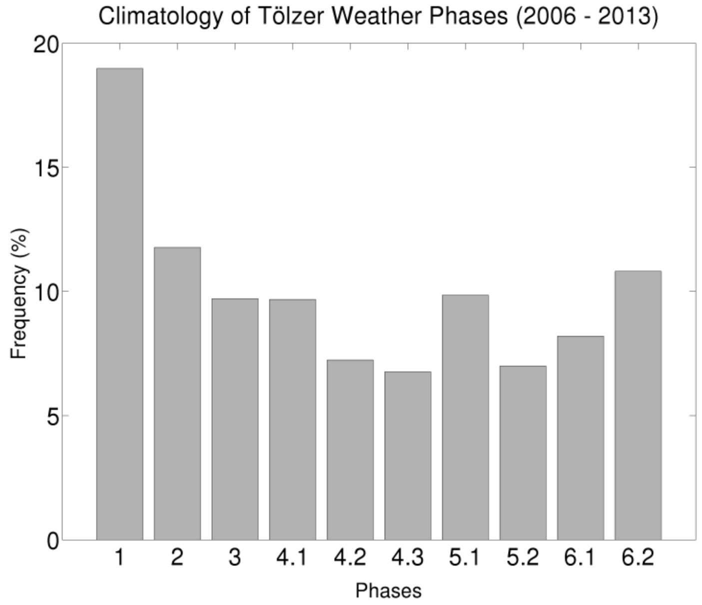

Fig. 4 Frequency of Tölzer phases for the period 2006-2013 in Berlin.

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