Impact of temperature and atmospheric pressure on the incidence of major acute cardiovascular events

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Abstract

Background The impact of meteorological conditions on the occurrence of various cardiovascular events has been reported internationally. Data about the Dutch situation are limited.

Objectives We sought to find out a correlation between weather conditions and the incidence of major acute cardiovascular events such as type A acute aortic dissection (AAD), acute myocardial infarction (AMI) and acutely presented abdominal aortic aneurysms (AAAA).

Methods Between January 1998 and February 2010, patients who were admitted to our hospital (Catharina Hospital, Eindhoven, the Netherlands) because of AAD ($n=212$), AMI ($n=11389$) or AAAA ($n=1594$) were registered. These data were correlated with the meteorological data provided by the Royal Dutch Meteorological Institute (KNMI) over the same period.

Results During the study period, a total number of 11,412 patients were admitted with AMI, 212 patients with AAD and 1593 patients with AAAA. A significant correlation was found between the daily temperature and the number of hospital admissions for AAD. The lower the daily temperature, the higher the incidence of AAD ($p=0.002$). Lower temperature was also a predictor of a higher incidence of AMI ($p=0.02$). No significant correlation was found between daily temperature and onset of AAAA.

Conclusions Cold weather is correlated with a higher incidence of AAD and AMI.

Keywords Epidemiology · Cardiovascular diseases · Atmospheric conditions · Statistics

Introduction

In winter, the incidence of death within the general population is higher than in the summer. Data from the Dutch Central Bureau of Statistics show that the overall mortality rate in the general Dutch population is lowest at an average daily temperature around 17°Celsius and lower ambient temperature correlates with an increase in cardiovascular mortality in the Netherlands [1].

The more the average daily temperature fluctuates, the higher the mortality. At the beginning of the 20th century, there were seasonal patterns of mortality for infants, children and adults. The death rate in January and February was twice as high as in the period from July to September. The fluctuations in mortality only became more pronounced for people over 60 years of age. Nowadays, mortality rates for the elderly are about 20% higher in winter than in summer. Probably, this persistent seasonal fluctuation is partly because of the fact that cardiovascular diseases are more prevalent in the elderly [1].

Several studies have examined the relationship between weather variables and the incidence of acute cardiovascular events, such as type A acute aortic dissection (AAD), acute myocardial infarction (AMI) and acutely presented abdominal aortic aneurysms (AAAA) [2–8]. In this retrospective study, we sought to find out a correlation between these events and the atmospheric conditions, temperature and air pressure.

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Table 1 Number of daily admissions for major acute cardiovascular events

	Minimum	Maximum	Mean	SD
AMI	0	13	2.57	2.123
AAAA	0	4	.36	.636
AAD	0	1	.05	.213

AMI=acute myocardial infarction; AAD=acute type A aortic dissection; AAAA=acute abdominal aortic aneurysm; SD=standard deviation

Methods

From January 1998 until February 2010 daily minimum and maximum temperatures and air pressures were retrieved from the database from the Royal Dutch Meteorological Institute (KNMI). This organisation collects all the data concerning the weather in the Netherlands. The data from weather station Eindhoven were downloaded from the internet (www.knmi.nl) and collected in a database. During the same period, data were derived from the Catharina Hospital database concerning admissions for acute AMI, AAD, and AAAA. Catharina Hospital is located in the south-east of the Netherlands. All referred patients lived within a radius of up to 50 km from our hospital.

Statistical analysis

Univariate linear regression analyses were performed to investigate a correlation between daily minimum and maximum temperatures and minimum and maximum air pressures and the number of admissions for AMI and AAAA. Standardised coefficients (Beta) were calculated. Because

the maximum number of daily admissions for AADs was 1, binary logistic regression analyses were performed to be able to calculate odds ratios (OR). ORs with 95% confidence intervals were calculated. In addition, the differences between daily temperatures and air pressures and the values of 3 days earlier were entered as a variable in the logistic regression analyses to be able to study the effect of changes in weather conditions. Multivariate linear regression analyses were performed entering daily temperatures and air pressures. Variables tested in the univariate binary logistic regression analyses with p-values <.05 were entered into a multivariate binary logistic regression analysis together with the month of admission.

Results

During the study period (January 1998 to February 2010) a total of 11,412 patients were admitted with AMI, 212 patients with AAD and 1593 patients with AAAA. An overview of the number of admissions per day is shown in Table 1.

Figure 1 shows the minimum daily temperatures together with the number of admissions for AMI. Temperature is shown on the Y1 axis and the number of AMIs is shown on the Y2 axis. Date of admission for AMI is shown on the X axis. The correlation between temperature and AMI is shown for each day. There does not seem to be any clear seasonal pattern. Increase in number of AMIs since 2007 is due to a change in the treatment of AMIs. Since that time AMIs are treated with acute percutaneous coronary intervention.

Table 2 shows the downloaded data from Eindhoven weather station. The minimal and maximal temperatures are displayed in degrees Celsius and minimal and maximal air pressures are displayed in hectoPascal.

Fig. 1 Daily minimal temperatures and number of admissions for AMI (AMI=acute myocardial infarction)

Table 2 Daily temperature and air pressure

Variable	Minimum	Maximum	Mean	SD
Minimal temperature ^a	−18.2	20.9	6.0	5.8
Maximal temperature ^a	−5.3	36.6	14.9	7.6
Maximal air pressure ^b	983.5	1045.8	1018.5	905.8
Minimal air pressures ^b	963.2	1043.0	1012.3	10.3

^a degrees Celsius; ^b hectoPascal

Results of the univariate linear regression analyses are shown in Table 3. The minimal temperature was inversely correlated with the number of daily admissions for AMIs. When the temperatures and air pressures were entered into a multivariate linear regression analysis, only the minimum temperature was independently correlated with the number of AMIs (Beta −0.37 p-value .014). Neither the air pressures nor the difference in air pressure between the day of admission and 3 days before had a correlation with any of the admissions. None of these variables had a significant correlation with admissions for AAAA.

Results of the binary logistic regression analyses for dissections are shown in Table 4. The daily minimal and maximal temperatures were significant predictors for admission for AAD.

When the month of admission was entered into a multivariate binary logistic regression analysis together with the minimal and maximal temperatures, both values of daily temperatures were independent predictors of admissions for AAD. The OR for the minimal temperature was 0.995 (p-value=.010) and OR for the maximal temperature was 0.996 (p-value=.024).

Discussion

This retrospective study shows that the minimal temperature was inversely correlated with the incidence of AMI and AAD. No significant correlation was found between daily

Table 3 Results of the univariate linear regression analyses

Variable	AMI		AAAA	
	Beta	p-value	Beta	p-value
Minimal temperature	−0.035	0.020	0.013	0.394
Maximal temperature	−0.027	0.073	0.006	0.706
Δ temperature	−0.019	0.215	0.004	0.766
Minimal pressure	−0.012	0.414	0.005	0.746
Maximal pressure	−0.012	0.431	0.002	0.911
Δ pressure	0.003	0.834	0.010	0.495

Δ=difference between day of admission and 3 days earlier. AMI=acute myocardial infarction, AAAA=acute abdominal aortic aneurysm

Table 4 Results of the binary logistic regression analyses for acute aortic dissections

	Odds ratio	p-value
Minimal temperature	0.996(0.994–0.999)	.002
Maximal temperature	0.997(0.995–0.999)	.002
Δ temperature	1.001(0.998–1.004)	.486
Minimal pressure	0.999(0.998–1.000)	.083
Maximal pressure	1.000(0.998–1.001)	.658
Δ pressure	1.001(1.000–1.002)	.212

Δ=difference between day of admission and 3 days earlier

temperature and onset of AAAA. Many studies have already examined the effects of weather on the incidence of AMI, AAAA and AAD [2–4]. However, most of these studies only examined the effect of local weather on the different cardiovascular events. Our study investigates the incidence of all three events in the same population in one topographic region with minimal differences in demographic profiles.

The association between the occurrence of AMI and meteorological factors was examined in a large number of studies with a wide variation in methodology and reporting. Most of studies observed a relationship between temperature and the incidence of AMI. To our knowledge, besides this study, only three other studies had a large data source with over 10,000 patients [9–11]. These studies found detrimental effects of cold weather on the incidence of AMI. However, in these studies there are some limitations. Two of these studies did not adjust for atmospheric pressure [9, 10]. In our study only detrimental effects of cold with adjustment for atmospheric pressure were found. The other study only reported on fatal events [11], we included all coronary events admitted to our hospital.

We did not observe any correlation between low atmospheric pressure or temperature and the incidence of AAAA. Although earlier studies adjusted their results with monthly temperature, no direct correlation between AAAA and daily temperature has been proven so far in the literature.

The influence of meteorological conditions on the occurrence of AAD has been reported by several authors [4–6]. However, only evidence was found for a higher incidence in correlation with low atmospheric pressure⁴ and significant circadian and seasonal variations [5]. So far only one of these studies showed statistically significant differences between decrease in outdoor temperature and incidence of AAD [4]. We were only able to correlate lower ambient temperature with a higher incidence of AAD. The decrease of temperature during the days preceding the occurrence of AADs was not a significant predictor of AAD. There was no correlation with atmospheric pressure either. Our findings suggest that the incidence of AAD could be higher in countries with a cold climate, although no significant

correlation was found in the literature between AADs and demographic distribution [5–14]. However, regarding mortality and AMI, it has been shown that rather an adaptation of inhabitants of colder regions to the cold can be expected [15].

The influence of atmospheric temperature on the incidence of AADs may be explained by an increase in sympathetic activity, which is responsible for higher blood pressure, and heart rate. AADs result from the association of various factors, among which hypertension plays a key role as a predisposing factor, and as a trigger factor [16]. In 1982, Brennan et al. observed an increase in the mean blood pressure in winter in large samples of treated and untreated subgroups of patients with high blood pressure [17]. Benouaich et al. suggest a link between high blood pressure, adverse cardiovascular events and cold atmospheric temperature because of an adrenergic-mediated increase of blood pressure due to cold [4]. We agree with Edwin et al. that the pathogenesis of AAD could be the result of the interaction of three factors: a predisposition provided by an abnormality or weakening of the aortic media, an agent of intimal injury or tear resulting in the intimo-medial flap, and haemodynamic factors that propagate the dissection once it has been initiated [18]. Predisposing factors of AAD should be distinguished from precipitating factors. Our study demonstrates that a relative decrease in environmental temperature is clearly a precipitating factor of AAD.

Limitations to our study

This is a retrospective observational study. Therefore, we must be cautious in interpreting our results. This study is based on hospital admissions. Major events leading to out-of-hospital deaths may not have been included.

Conclusions

The lower the air temperature, the higher the incidence of acute myocardial infarction and type A aortic dissection. No correlation between air pressure and these events was found in this study.

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