Effect of Season and Climate on in-hospital Mortality and Length of Stay for Patients With Type A Aortic Dissection

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Research Article

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Abstract

Objective: To investigated the effects of seasonal and climatic changes on in-hospital mortality and length of stay (LOS) for postoperative patients with type A acute aortic dissection (AAD).

Methods: The clinical data of 404 patients diagnosed with type A AAD in our hospital and the relevant meteorological data were retrospectively collected and analyzed from January 2016 to December 2019.

Results: The multivariate unconditional logistic regression analysis showed that admission in autumn (OR=4.027, 95% CI=1.023-17.301) and coronary heart disease (odds ratio OR=7.669, 95% CI=1.20-48.689) were increased risk factors for postoperative in-hospital mortality in patients with type A AAD; admission in autumn (95% CI=2.719-7.921, P=0.041) and hypertension (95% CI=1.192-5.106, P=0.035) for type A AAD patients were increased risk factors for LOS.

Conclusion: Patients with admission in autumn or coronary heart disease appeared to increasing effects on postoperative in-hospital mortality for type A AAD. Patients with admission in autumn or hypertension seemed to be associated with longer LOS.

Introduction

Acute aortic dissection(AAD) is one of the cardiovascular diseases with the highest mortality rate. Especially, Stanford type A AAD is a life threatening cardiovascular event that requires emergent surgical intervention.[1] Therefore, identification of risk factors which affect prognosis is of great value for risk stratification. Previous studies had shown that cardiovascular conditions such as coronary heart disease, stroke, supra-ventricular tachycardia and heart failure were associated with seasonal variations.[2–4] The incidence of these events showed distinct seasonal patterns, with peak admission during the winter. Also, previous studies shown that the incidence of type A AAD peaks was in winter and lowest in summer and the average temperature on the day with AAD was higher than that without AAD.[5–8] Here was a lack of data on the association between onset season and climate with in-hospital mortality and length of stay (LOS) in postoperative patients with AAD. The purpose of this study was to assess the effects of seasonal and climatic factors on postoperative in-hospital mortality and LOS in patients with AAD.

Patients And Method

The clinical variables data of AAD were collected and analyzed in Fujian province, China from January 2016 to December 2019. The collection of medical records were completed by one researcher, which contained the record of the patients' age, gender, diabetes, hypertension, coronary heart disease, chronic obstructive pulmonary disease (COPD), admission route, history of weekend surgery and other past medical history, diagnosis, AAD onset time and LOS. Another researcher created a database with Excel software, input and verify the data.

It is a typical southern hemisphere temperate monsoon climate with four distinct seasons in Fujian province, China. Meteorological data were provided by the Fujian Meteorological Bureau in the same period. Record of the daily minimum temperature, the average minimum temperature, the daily temperature difference, the average daily temperature difference and the average air quality index (AQI) were collected from January 2016 to December 2019. All the data were recorded by a single person. A database of meteorological data was created with Excel software, and the data were inputted and verified by the same researcher.

The classification of seasons is as follows: autumn (September 21 to December 20), winter (December 21 to March 21), spring (March 22 to June 21), and summer (June 22 to September 20). Based on the quartile of the average minimum temperature, it could be divided into < 11℃, 11–16℃, 16–23℃ and > 23℃. Outcome indicators were postoperative in-hospital mortality and LOS of survivors.

Statistical Analysis

Data analysis were performed using the IBM SPSS Statistics 23.0 software pack. A descriptive analysis was performed, including reports of percentages, means and standard deviations, to characterize the participants. Cross-sectional analysis was performed on variables hypothesized to be related to in-hospital mortality and LOS, chi-square tests were used for categorical variables, and analysis of variance (ANOVA) was used for two or more grouped variables. To test the hypothetical continuous variable's association with in-hospital mortality and LOS, Tukey's post hoc range test was used to compare the means of each group to arrive at a significant ANOVA. The $P < 0.05$ was considered statistically significant for all analyses, Non-normally distributed variables were analyzed by non-parametric tests (Mann-Whitney U test and Kruskal-Wallis H test). Univariate and multiple logistic regression analyses were conducted to test the relationship between seasonal and climatic variation and in-hospital mortality, the demographic covariates of age and gender, average minimum temperature, average daily temperature difference, average AQI, weekend surgery as well as the risk profile covariates of hypertension, diabetes, coronary heart disease and COPD. A multiple regression analysis was performed, using the same covariates which were used in the above multiple logistic regression analysis to investigate the predictors of LOS in postoperative survivors. LOS appeared positively skewed and showed kurtotic, and we used the natural logarithmic transformation of LOS to correct the non-normality of the analysis, and the power was returned to the geometric mean, and the 95% confidence interval (95% CI) was appropriately reported.

Result

1. General information: the average age of 404 patients was 52.96 ± 11.73 years, of which 74.3% were male. 4.5% of the patients died before discharge from hospital (n = 18), of which 77.8% were male (n = 14). 72% patients suffered from hypertension, 2.2% suffered from diabetes, 2.0% suffered from coronary heart disease, and 0.7% suffered from COPD.

2. Seasonal and climatic effect on in-hospital mortality of patients with AAD.

2.1 The chi-square test found seasonal difference in in-hospital mortality: admission in autumn increase in-hospital mortality (P = 0.026). No other climatic effect on in-hospital mortality: average minimum temperature on the day of onset (P = 0.066), average daily temperature difference (P = 0.605), average AQI (P = 0.720). In addition, the in-hospital mortality in patients with coronary heart disease was higher than that in patients without coronary heart disease (P = 0.004); the in-hospital mortality in outpatient admission patients was higher than that in emergency admission patients (P = 0.036). (Table 1)

2.2 The univariate unconditional logistic regression analysis results also showed difference in seasonal effect on in-hospital mortality: admission in autumn increased in-hospital mortality (OR = 4.159, 95% CI = 1.042–16.604). no other climatic effect on in-hospital mortality: average minimum temperature on the day of onset, average daily temperature difference and average AQI. In addition, the patients with coronary heart disease (odds ratio OR = 7.917, 95% CI = 1.480-42.335) was an increased risk factor and emergency admission patients (OR = 0.317, 95% CI = 0.102–0.980) was an protective factor for in-hospital mortality. (Table 2)

2.3 The multivariate unconditional logistic regression analysis showed seasonal factor: admission in autumn (OR = 4.027, 95% CI = 1.023–17.301) increased in-hospital mortality; another risk profile covariate: coronary heart disease (odds ratio OR = 7.669, 95% CI = 1.20-48.689) was also an increased risk factor for in-hospital mortality. (Table 3)

3. Linear regression analysis of seasonal risk factors for LOS in survivors after surgery.

3.1 Because of the non-normal distribution of hospital stay days, non-parametric tests (Mann-Whitney U test and Kruskal-Wallis H test) were used to analyze the relationship between the above demographic and risk profile covariates with LOS. univariate analysis results showed that hypertension (P = 0.012) and admission season (P = 0.046) were significantly related to LOS: patients with hypertension and admission in autumn were increased risk factors for LOS. (Table 4)

3.2 The results of multiple regression analysis showed that admission season (95% CI = 2.719–7.921, P = 0.041) and hypertension (95% CI = 1.192–5.106, P = 0.035) were significantly related to LOS of the patients: patients with hypertension and admission in autumn were increased risk factors for LOS. (Table 5)

Discussion

The mechanism of the AAD proves to be multifactorial. However, three key factors has been consistently agreed: weakened aortic wall, damaged vascular endometrium resulting of the vascular endothelial slap and the spread of endometrial damage due to hypertension .[9] Previous studies had proved many cardiovascular risk factors were related to seasonal and climatic changes including external environmental factors such as temperature and UV radiation, lifestyle such as diet, obesity, exercise and smoking, and other factors such as blood pressure, serum cholesterol, glucose tolerance, coagulation, acute and chronic infections.[10,11] All these risk factors were more common in winter and might also cause seasonal changes in the incidence of AAD.[12,13] Many previous studies suggested a possible seasonal effect on the onset of AAD by reporting a high incidence of AAD in winter and a low incidence of AAD in summer. [5–8] In winter, the temperature was low, the sympathetic nervous system of the human body was activated, and catecholamine secretion was increased to cope with low temperature, which leaded to increasing heart rate and peripheral vascular resistance, resulting in increased blood pressure. Cold environment promoted the occurrence of high blood pressure, and by increasing blood friction against the vascular wall and surface shear stress, high blood pressure increased the risk of the occurrence and rupture of aortic dissection in patients with hypertension history.[14] However, rare study had been conducted on the seasonal and climatic effect on the postoperative prognosis of AAD patients.

Non-accidental mortality has been reported to increase significantly in the transitional season in the general population. It has also been reported that mortality distribution in the transition season in Russia showed that the increase in mortality from hot to cold (autumn) was greater than that from cold to hot (spring).[15] It is also observed that large diurnal temperature variation lead to increased risk of cardiac mortality in autumn.[16,17] Unlike the seasonally and climatically regular pattern of the incidence of AAD, our univariate regression analysis found that among the seasonal and climatic high risk factors for postoperative in-hospital mortality of AAD, patients' admission day in autumn were more likely to die after surgery than other seasons, multivariate regression analysis also showed the admission day in autumn was a contributor to increased in-hospital mortality, although we found no significant link between climatic factors such as average minimum temperature on the day of onset, average daily temperature difference and average AQI and in-hospital mortality. Many studies have shown that seasonal meteorological variables affect blood pressure in hypertensive and normotensive individuals.[18–20] In china, it becomes cool and humid due to frequent rainfall in autumn, and atmospheric pressure (AP) fluctuates intensely.[21] The drop in temperature and fluctuation in AP may lead to increased sympathetic activity, causing more severe vasoconstriction or vasospasm, higher blood pressure.[22] Some studies have confirmed that the fluctuation of AP might increase the risk of rupture in abdominal aortic aneurysm.[23,24] In the same way, drastic fluctuations of systolic blood pressure result from increased alteration of AP in autumn can cause greater risk of postoperative residual dissection rupture, leading to statistically significant higher in-hospital mortality rate in our study. Another reason was that meteorological risk factors including humidity, rainfall and other specific climatic data also may have provided a more detailed explanation for the seasonal and climatic impacts. [25] And other currently unknown and related risk factors might also have an impact. In addition, when used a univariate and multiple logistic regression analysis to analyze all predictors of postoperative AAD in-hospital mortality, it could be found that coronary heart disease also caused the increase of postoperative AAD in-hospital mortality, indicating that timely intervention of coronary heart disease may reduce postoperative in-hospital mortality.

When used a multiple logistic regression analysis in the second study to determine whether there were seasonal and climatic high risk factors associated with LOS. It could still be found that there were statistical difference in the LOS and seasonal high risk factor: admission day in autumn seemed to prolong LOS; but climatic high risk factors (average minimum temperature of the onset day, average daily temperature difference and average AQI) were not contributors to increase LOS. In addition, patients with hypertension might prolonged LOS.

Limitations

This study had some inevitable limitations. First, data were limited to some patients underwent surgery in a single center in our hospital, our findings might not be necessarily reflected in other countries with more seasonal and climatic risk model. The second limitation was the relationship among mortality, LOS, season and climate might also be affected by other administrative and logistical unknown variables.

Conclusion

Admission in autumn, coronary heart disease and outpatient admission appeared to a increase the chance of postoperative AAD in-hospital mortality. Meanwhile, patients admitted in autumn with hypertension seemed to be associated with longer LOS, however, the conclusions deserve further study to confirm.

Abbreviations

LOS: length of stay; AAD: acute aortic dissection; AP: atmospheric pressure; AQI: air quality index; COPD: chronic obstructive pulmonary disease

Declarations

Ethical Approval and Consent to participate:

The present study was approved by the ethics committee of Fujian Medical University, China and adhered to the tenets of the Declaration of Helsinki.

Consent for publication:

Not applicable

Availability of Data and Materials:

Data sharing not applicable to this article as no data sets were generated or analyzed during the current study.

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Competing interests:

All authors declare that they have no competing interests.

Author Contributions:

Zeng-Rong Luo designed the study. Zeng-Rong Luo, Zhi-Qin Lin and Han-Fan Qiu collected and analyzed data together. Zeng-Rong Luo drafted the article and submitted the manuscript. Liang-Wan Chen supervised this study. All authors read the final version of this article and approved for publication.

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Tables

Table 1 The Chi-square test of covariates for in-hospital mortality

covariates		survive	death	χ^2	P
Age(Year)	18-44	91(97.8%)	2(2.2%)	3.057	0.383
	45-59	165(93.8%)	11(6.3%)		
	60-74	119(96.0%)	5(4.0%)		
	75-89	11(100.0%)	0(0.0%)		
Gender	Male	300(95.5%)	14(4.5%)	0.000	0.995
	Female	86(95.6%)	4(4.4%)		
hypertension	NO	107(94.7%)	6(5.3%)	0.269	0.604
	YES	279(95.9%)	12(4.1%)		
coronary heart disease	NO	380(96.0%)	16(4.0%)	8.092	0.004
	YES	6(75.0%)	2(25.0%)		
diabetes	NO	378(95.7%)	17(4.3%)	0.958	0.328
	YES	8(88.9%)	1(11.1%)		
COPD	NO	383(95.5%)	18(4.5%)	0.141	0.707
	YES	3(100.0%)	0(0.0%)		
Average minimum temperature on the day of onset (°C)	<11.00	83(98.8%)	1(1.2%)	7.208	0.066
	[11.00,16.00]	112(95.7%)	5(4.3%)		
	(16.00-23.00]	98(97.0%)	3(3.0%)		
	>23.00	93(91.2%)	9(8.8%)		
average daily temperature difference (°C)	<5.00	75(97.4%)	2(2.6%)	1.848	0.605
	[5.00,7.00]	136(93.8%)	9(6.2%)		
	(7.00,9.00]	105(96.3%)	4(3.7%)		
Air Quality Index, AQI	>9.00	70(95.9%)	3(4.1%)		
	0-50	244(94.9%)	13(5.1%)	0.658	0.720
	51-100	140(96.6%)	5(3.4%)		
Season*	101-150	2(100.0%)	0(0.0%)		
	Spring	74(93.7%)	5(6.3%)	9.225	0.026
	Summer	69(90.8%)	7(9.2%)		
	Autumn	108(87.8%)	15(12.2%)		
Weekend surgery history	Winter	123(97.6%)	3(2.4%)		
	NO	313(95.7%)	14(4.3%)	0.122	0.727
Admission route	YES	73(94.8%)	4(5.2%)		
	Outpatient admission	203(93.5%)	14(6.5%)	4.388	0.036
	emergency admission	183(97.9%)	4(2.1%)		

* Season : Spring (March 22 to June 21)

Summer (June 22 to September 20)

Autumn (September 21 to December 20)

Winter (December 21 to March 21)

Table 2 The univariate unconditional logistic regression analysis of covariates for in-hospital mortality

covariates		survive	death	OR(95%CI)
Age(Year)	18-44	91(97.8%)	2(2.2%)	1.000
	45-59	165(93.8%)	11(6.3%)	3.033(0.658,13.984)
	60-74	119(96.0%)	5(4.0%)	1.912(0.363,10.079)
	75-89	11(100.0%)	0(0.0%)	—
Gender	Male	300(95.5%)	14(4.5%)	1.000
	Female	86(95.6%)	4(4.4%)	1.003(0.322,3.127)
hypertension	NO	107(94.7%)	6(5.3%)	1.000
	YES	279(95.9%)	12(4.1%)	0.767(0.281,2.095)
coronary heart disease	NO	380(96.0%)	16(4.0%)	1.000
	YES	6(75.0%)	2(25.0%)	7.917(1.480,42.335)
diabetes	NO	378(95.7%)	17(4.3%)	1.000
	YES	8(88.9%)	1(11.1%)	2.779(0.329,23.503)
COPD	NO	383(95.5%)	18(4.5%)	1.000
	YES	3(100.0%)	0(0.0%)	—
Average minimum temperature on the day of onset (℃)	<11.00	83(98.8%)	1(1.2%)	1.000
	[11.00,16.00]	112(95.7%)	5(4.3%)	3.705(0.425,32.314)
	(16.00-23.00]	98(97.0%)	3(3.0%)	2.541(0.259,24.890)
	>23.00	93(91.2%)	9(8.8%)	8.032(0.996,64.750)
average daily temperature difference (℃)	<5.00	75(97.4%)	2(2.6%)	1.000
	[5.00,7.00]	136(93.8%)	9(6.2%)	2.482(0.523,11.785)
	(7.00,9.00]	105(96.3%)	4(3.7%)	1.429(0.255,8.002)
Air Quality Index, AQI	>9.00	70(95.9%)	3(4.1%)	1.607(0.261,9.905)
	0-50	244(94.9%)	13(5.1%)	1.000
	51-100	140(96.6%)	5(3.4%)	0.670(0.234,1.920)
Season*	101-150	2(100.0%)	0(0.0%)	—
	Spring	74(93.7%)	5(6.3%)	1.000
	Summer	69(90.8%)	7(9.2%)	2.770(0.643,11.930)
	Autumn	108(87.8%)	15(12.2%)	4.159(1.042,16.604)
Weekend surgery history	Winter	123(97.6%)	3(2.4%)	1.025(0.203,5.179)
	NO	313(95.7%)	14(4.3%)	1.000
Admission route	YES	73(94.8%)	4(5.2%)	1.225(0.392,3.831)
	Outpatient admission	203(93.5%)	14(6.5%)	1.000
	Emergency admission	183(97.9%)	4(2.1%)	0.317(0.102,0.980)

* Season : Spring (March 22 to June 21)

Summer (June 22 to September 20)

Autumn (September 21 to December 20)

Winter (December 21 to March 21)

Table 3 The multivariate unconditional logistic regression analysis of covariates for in-hospital mortality

covariates	β	Waldχ^2	P value	OR	95%CI
coronary heart disease	2.037	4.667	0.031	7.669	(1.208,48.689)
Autumn	0.986	3.264	0.039	4.027	(1.023,17.301)

Table 4 The Mann-Whitney U test and Kruskal-Wallis H test analysis of covariates for LOS

covariates		Cases(%)	M	(P_{25},P_{75})	χ^2/Z	P
Age(Year)	18-44	93(23.0%)	18	(14,24)	5.008	0.171
	45-59	176(43.6%)	18	(15,26)		
	60-74	124(30.7%)	20.5	(16,27)		
	75-89	11(2.7%)	21	(17,26)		
Gender	Male	90(22.3%)	20	(15,26)	-0.203	0.839
	Female	314(77.7%)	19	(15,25)		
hypertension	NO	113(28.0%)	17	(14,23)	-2.502	0.012
	YES	291(72.0%)	20	(15,27)		
coronary heart disease	NO	396(98.0%)	19	(15,25)	-0.794	0.427
	YES	8(2.0%)	25	(14,43)		
diabetes	NO	395(97.8%)	19	(15,25)	-0.107	0.915
	YES	9(2.2%)	20	(16,27)		
COPD	NO	401(99.3%)	19	(15,26)	-1.418	0.156
	YES	3(0.7%)	14	(8,20)		
Average minimum temperature on the day of onset (℃)	<11.00	84(20.8%)	19	(15,27)	4.502	0.212
	[11.00,16.00]	117(29.0%)	19	(15,24)		
	(16.00-23.00]	101(25.0%)	18	(15,23)		
	>23.00	102(25.2%)	22	(16,31)		
average daily temperature difference (℃)	<5.00	77(19.1%)	20	(14,25)	2.100	0.552
	[5.00,7.00]	145(35.9%)	18	(15,26)		
	(7.00,9.00]	109(27.0%)	19	(15,24)		
	>9.00	73(18.1%)	20	(17,27)		
Air Quality Index, AQI	0-50	257(63.6%)	19	(14,25)	0.647	0.724
	51-100	145(35.9%)	19	(15,26)		
	101-150	2(0.5%)	18	(17,18)		
Season*	Spring	79(19.6%)	19	(15,25)	7.975	0.046
	Summer	76(18.8%)	18	(14,24)		
	Autumn	123(30.4%)	23	(16,33)		
	Winter	126(31.2%)	19	(14,25)		
Weekend surgery history	NO	327(80.9%)	19	(15,27)	-0.085	0.933
	YES	77(19.1%)	21	(14,24)		
Admission route	Outpatient admission	217(53.7%)	20	(15,25)	-0.670	0.503
	emergency admission	187(46.3%)	18	(15,26)		

* Season : Spring (March 22 to June 21)

Summer (June 22 to September 2)

Autumn (September 21 to December 20

Winter (December 21 to March 21)

Table 5 Multivariate Linear Regression Analysis of covariates for LOS

covariates	Unstandardized Coefficients B	Standard error	Standardized Coefficients Beta	t	P	95%CI
Hypertension	2.649	1.250	0.105	2.119	0.035	(1.192,5.106)
Autumn	1.368	0.762	0.886	1.756	0.041	(2.719,7.921)