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A STUDY OF CIRCADIAN RHYTHM AND METEOROLOGICAL FACTORS INFLUENCING ACUTE MYOCARDIAL INFARCTION

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Abstract

The circadian rhythm in the occurrence of myocardial infarction (AMI) was assessed in three hundred and twenty three patients admitted with AMI during the two-year period June 1992 to May 1994. The influence of the following meteorological, solar-geophysical and cosmic parameters in the causation of an infarct was also considered : (1) surface pressure (2) maximum temperature (3) minimum temperature (4) relative humidity (5) cosmic ray index (6) geomagnetic **aa** index (7) solar flares and (8) sunspot number.A well pronounced diurnal variability in AMI with a peak in the morning hours (6-12 a.m.) was seen. Further analysis of the data by considering one-hour periods revealed the presence of a smaller evening (10 p.m.) increase in incidence, i.e., the existence of a bimodal circadian rhythm. The simultaneous occurrence of the well documented semi-diurnal rhythm in surface pressure and incidence of acute myocardial infarction were evident. This may be one of the factors involved in the causation of the smaller evening peak-the reasons for which were unclear till now. Month-to-month variation in surface pressure was also found to be significantly correlated with incidence of acute myocardial infarction. Recognition of a circadian rhythm in the onset of AMI suggests the need for enhanced pharmacological protection during the vulnerable periods. Significant correlations were also found between monthly incidence of AMI and month-to-month variation of cosmic ray index and solar flare counts. The pattern of incidence of AMI was seen to be modified by full moon and new moon. There was no association between maximum temperature, minimum temperature or relative humidity and incidence of AMI.

Keywords : Acute myocardial infarction (AMI) - AMI and meteorological parameters - AMI and surface pressure - AMI and solar activity

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This paper gives results pertaining to meteorological influence on AMI reported in the dissertation of the same title submitted to the university of Pune by Dr.Sen,M.B.B.S. in May 1995 for the M.D(Doctor of Medicine) Degree(General Medicine) Branch 1.

1. Introduction

Acute myocardial infraction (AMI) is one of the leading causes of death in adults. The last two decades have witnessed rapid strides in the management of acute myocardial infarction. Consequently there is a significant reduction in the mortality from AMI and most of the death from infarction now occur before medical care is available. This realization has led to a renewed interest in primary prevention and the probable triggering factors in the causation of AMI. Several major studies have demonstrated a circadian (diurnal) variation in AMI incidence with a peak in the morning hours (Master 1960; Muller et al. 1985; Gilpin et al. 1990; Ridker et al. 1990; Hansen et al. 1992; Willich 1990; Levine et al. 1992; Mulcahy et al. 1988; Lucente et al. 1988).

Prominent and reproducible temporal patterns occurring regularly over twenty four hour periods are referred to as circadian rhythms. Many physiological processes exhibit circadian rhythm. A few prominent examples include sleep and wakefulness, blood pressure, growth hormone release etc. (Ganong 1989). This normal circadian rhythm is influenced by both internal control and external factors. The observed diurnal variation in acute coronary syndromes had been attributed to a complex interplay between internal and external factors (Rocco 1990).

Recognition of a circadian rhythm in the onset of acute cardiovascular events suggests the need for enhanced pharmacological protection during the vulnerable periods and provides clues to the mechanisms, the investigation of which may ultimately lead to improved methods of prevention (Muller et al. 1989).

Man is not immune to his meteorological environment. The possible relationship between sudden changes in weather and the development of diseased states has always generated curiosity among physicians and meteorological scientists. There has, however been a paucity of data concerning the association between changes in weather and the development of AMI.

The present study is an attempt to define the circadian variation in symptom onset of AMI with reference to possible modifying factors. The study also examines the correlation between a few meteorological factors, solar activity and the incidence of AMI. All cases of AMI admitted to a leading Institute of Cardiology in Pune,India during the 2-year period June 1992 to May 1994 were used in the study.

2. The region and its climate

Pune (18°32'N, 73°51'E) is a hill station 559 m above mean sea level. It is an urban station about 100 km inland from the west coast of India.

The meteorological conditions in the region is classified into the following four major seasons : (1) Winter (DJF : December, January, February), (2) Premonsoon (MAM: March, April, May), (3) Monsoon (JJA : June, July, August), (4) Postmonsoon (SON: September, October, November).

The surface pressure variations and associated weather activity in the region is influenced to a large extent by the seasonal migration of the Intertropical Convergence Zone (ITCZ) which follows the sun from the southern hemisphere in winter to the northern hemisphere in summer. Figure 1 gives the location of ITCZ during January (winter) and July (summer). A brief description of ITCZ is given in the following. From geometrical considerations, the latitude of 23.5°N is called the Tropic of Cancer and the latitude of 23.5°S is called the Tropic of Capricorn. The region between these two sides of the geometrical equator is called the tropical region. However, the weather systems of the two hemispheres are not geometrically fixed like the geometrical latitudes. These move with the sun. During the northern (southern) summer season, the weather systems of both hemispheres shift towards the north (south). The center of the weather systems of the two hemispheres is to the north of the geometrical equator during northern summer and to the south of the geometrical equator during the southern summer. This center of the weather systems is called the meteorological equator or the Inter Tropical Convergence Zone (ITCZ) (Asnani 1993). ITCZ is a region of low pressure associated with cloudy conditions and rainfall. The northward movement of ITCZ into the Indian region from May to July is associated with summer monsoon onset and rainfall. The southward migration of ITCZ from July to November heralds the gradual withdrawal of the summer monsoon over India. The average meteorological conditions during the four seasons are given below.

2.1 Winter (DJF)

Surface pressures are high with fair weather, clear skies, cold mornings, dry atmosphere and dust haze in the mornings. Surface winds are light and least gusty and surface minimum temperatures go down to 8°C.

2.2 Premonsoon (MAM)

The surface pressure begins to decrease. This is the hottest part of the year with temperatures reaching a maximum of 40°C. Surface winds are gusty and thundercloud development takes place on some days during the afternoon/evening hours. The dust content in the atmosphere is a maximum particularly in the afternoon/evening.

2.3 Monsoon (JJA)

The surface pressures are a minimum during this season. The strong monsoon air flow in the lower atmosphere brings in a large amount of moisture from the Arabian sea. Under the influence of large scale weather systems (depressions, cyclones in the Bay of Bengal, Arabian sea and their movement inland) the region gets light continuous/intermittent rain characteristic of monsoon rain. Atmospheric pollution and dust content is a minimum during the monsoon season.

2.4 Postmonsoon

The summer monsoon withdraws from the region following the migration of the ITCZ to the south. Surface pressure and air temperature begin to increase. The atmosphere is moist with high temperatures. Thunderstorms occur during this season.

The climatological normals for maximum and minimum temperatures, surface pressure and relative humidity are shown in Figure 2.

2.5 Diurnal Variation of Meteorological Parameter

The meteorological parameters exhibit diurnal (24-hour) variations, mostly influenced by day to night solar heating cycle. The surface air temperature shows a maximum during afternoon hours. The relative humidity is a function of air temperature and is in general maximum during early morning hours. The diurnal variation of all meteorological parameters except surface pressure is influenced by the weather activity over the region. Surface pressure exhibits a remarkably stable semidiurnal oscillation with maxima at 10 a.m. and 10 p.m. and minima at 4 a.m. and 4 p.m. local time. This semidiurnal oscillation in surface pressure is a universal phenomenon observed worldwide and can be identified even in disturbed weather conditions. The amplitude of the universal semidiurnal surface pressure oscillation is a maximum in the tropical regions. The semidiurnal pressure oscillation at Pune (Ananthakrishnan et al., 1984) is shown in Figure 3. The morning increase in surface pressure from 4 a.m. to 10 a.m. is about 1.5 mb and corresponds to an increase in load (atmospheric) of 15 kg/sq. metre.

3. Data , analysis and results

Data relating to a total of 323 patients of AMI admitted over the 2-year period June 1992 to May 1994, to a leading Institute of Cardiology, in Pune, India were used in this study.

The meteorological data used for the study, namely, maximum and minimum temperatures, relative humidity and surface pressure were obtained from India Meteorological Department.

Data relating to cosmic ray index (Climax neutron monitor pressure), geomagnetic **aa** index, grouped solar flare counts, smoothed sunspot number and 2800 Mhz (10.7 cm) solar flux data were obtained from the publication SOLAR-GEOPHYSICAL DATA, NOAA National Geophysical Data Center, Boulder, Colorado.

The complete data set (monthly totals/averages) used for the study is given in Table 1.

3.1 Circadian rhythm

For the population as a whole, the frequency of symptom onset was tabulated for each hour (local time) of the day and also for the four six-hour intervals 0000-0600, 0600-1200, 1200-1800 and 1800-2400.

Figure 4 shows the frequency of occurrence of AMI for the above defined four quarters of the day. The maximum number of infarcts (38.7%) occurred between 6 a.m. and 12 noon and this was found to be statistically significant.

The hourly frequency (annual) of occurrence of AMI shown in Figure 5a revealed the occurrence of a smaller peak in the late evening in addition to the morning peak. This double oscillation in the circadian rhythm of AMI is seen in the seasonal averages also (Figure 5b). The circadian rhythms during the four seasons are significantly correlated to the annual mean circadian rhythm (Table 2). The frequency of occurrence of AMI exhibits a broad maximum with peak at 10 a.m. and a smaller narrow peak at about 10 p.m.

The double oscillation in the circadian rhythm of AMI appears to resemble closely the double oscillation in surface pressure (Figure 3).

3.2 AMI and meteorological and solar geophysical parameters

The seasonal distribution (% of total) of the cases revealed a higher incidence during the postmonsoon (september to november), though the relationship was not significant statistically (Figure 6). This results is different from earlier studies elsewhere. The published reports from United Kingdom (West et al. 1973; Bainton et al 1977; Bull 1973), United States of America (Mannino et al. 1989) and other countries with predominantly cold weather (Sotanienni et al. 1970; Teng and Heyer 1955) revealed a higher incidence during winter, especially aggravated by sudden cold waves.

Al Yusuf et al (1986) reported a higher incidence of AMI during summer in Kuwait with predominantly hot dry climate.

The MILIS study and the study by Fogel and Righthand (1964) failed to show any seasonal variation in incidence.

The most important factor responsible for modifying the onset of myocardial infarction may be the sudden changes in weather (Al Yusuf 1986). The sudden shifts in weather were thought to overtax vasomotor mechanism producing an acute myocardial infarction.

The present study failed to show any statistically significant circ-seasonal rhythm in AMI incidence. Poona has comfortable weather conditions for most parts of the year irrespective of the season and this absence of marked seasonal variation may be responsible for this.

In order to investigate the association ,if any,between AMI and solar-geophysical parameters, graphs were drawn between monthly total AMI incidence and month-to-month variation of mean (a) surface pressure (Figure 7a) (b) cosmic ray index (Figure 7b) and (c) solar flare counts(Figure 7c). Figure 7d shows the month-to-month variation of AMI cases and total solar flare counts.It is seen that AMI incidence follows closely (positive correlation) the month-to-month variation of mean surface pressure,cosmic ray index and solar flare counts(Figures 7a to 7c).On the other hand ,AMI incidence shows a negative association(correlation) with total solar flare counts(Figure 7d).Statistical correlation coefficients were computed and shown in Table 3 for monthly total AMI incidence and month-to-month variation of mean surface pressure,cosmic ray index and solar flare counts(Figure 7a to 7c).Table 3 also shows the correlation coefficient between monthly total AMI incidence and total solar flare counts.

3.3 Lunar influence of AMI

The incidence of AMI was found to be modified by the phases of the moon. Maximum number of AMI occurred one day after full moon (Figure 8a) and the number of AMI cases are more on either side of (before and after) new moon (Figure 8b).

4. Discussion

A statistically significant peak in the occurrence of AMI was observed during the morning hours (6 a.m. to 12 noon) in agreement with earlier studies in other parts of the world (Behar et al. 1993; Chopra 1994). Analysis of hourly frequency of occurrence of AMI revealed a smaller peak in the late evening (10 p.m.) in addition to the morning peak. This double oscillation is seen in the annual and seasonal averages. Similar bimodal periodicity was seen in many of the earlier studies (Muller 1985; Gilpin et al. 1990; Hansen et al. 1992). The observed semidiurnal variation in AMI incidence appears to be in step with the universal semidiurnal oscillation in surface pressure.

4.1 AMI and meteorological parameters

There was no association between maximum temperature, minimum temperature or relative humidity and incidence of AMI. Statistically significant positive correlation was found between month-to-month variation of mean surface pressure, cosmic ray index, solar flare counts and monthly incidence of AMI. A negative correlation was seen between AMI and monthly total solar flares.

Incidentally, it is now established that surface pressure fluctuations are closely associated with cosmic rays and solar events such as solar flares, sunspots etc. (Herman and Goldberg 1985).

The close association between month-to-month variability in mean surface pressure and AMI incidence was also reported in a similar study in Bombay , India (Rodrigues and Pinto 1982) where the surface pressure changes and the associated AMI incidence were attributed to the movement of ITCZ (Inter-Tropical Convergence Zone). Teng and Heyer (1955) give reference to observed correlation between number of deaths from cardiovascular diseases and barometric pressure. Kveton (1991) reported that the association between the incidence of AMI and weather fronts were due to the variations in surface pressure.

Though a statistically significant association between AMI and surface pressure variation was demonstrated in the present study, it might not amount to causal association. Larger prospective studies over longer periods are mandatory before causality can be attached.

5. Conclusions

1. A circadian variation of symptom onset in acute myocardial infarction with an increased frequency in the morning (6 a.m to 12 noon) and possibly also in the evening(10 p.m.) was demonstrated.

2. There was no statistically significant seasonal or monthly variation in AMI.Significant correlation was found between the monthly incidence of AMI and month-to-month variation in surface pressure ,cosmic ray index and solar flare counts.The pattern of incidence was seen to be modified by full moon and new moon.No significant correlation was seen with the other meteorological parameters like temperature and relative humidity.

6. Acknowledgements

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TABLE 1

MONTHLY INCIDENCE OF AMI AND METEOROLOGICAL, COSMIC, SOLAR-GEOPHYSICAL PARAMETERS

	1992							1993												1994				
Parameter	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**
AMI (no.)	16	15	8	18	11	20	12	17	9	9	11	16	10	18	14	16	13	15	8	10	15	14	18	10
Surface Pres.(mb)	942.1	942.7	944.4	945.9	948.7	949.9	953.0	951.2	950.4	948.3	947.3	945.6	943.8	942.7	945.5	946.0	949.3	950.7	951.0	946.9	948.9	948.9	947.8	945.7
Max.Temp (°C)	32.3	29.8	27.1	29.5	30.0	30.1	27.8	30.1	31.5	34.9	37.9	37.1	34.3	27.9	27.1	29.3	29.4	28.3	26.0	27.4	30.5	36.3	36.4	36.5
Min.Temp (°C)	23.4	22.8	22.0	20.3	17.7	15.6	10.5	10.8	11.7	16.3	19.0	23.4	23.8	22.9	21.7	21.0	20.8	15.4	13.5	11.9	13.2	17.0	19.8	21.6
Relative Hum. (%)	67.8	77.7	84.3	78.4	73.3	67.3	64.0	60.5	48.1	43.3	34.5	47.1	66.0	81.6	82.5	79.7	81.4	66.3	74.1	68.6	56.7	39.8	47.7	53.6
Cosmic Ray Index	3830	3891	3892	3880	3941	3919	3988	3961	3959	3901	3955	3979	4012	4026	4027	4063	4073	4089	4073	4080	4030	4009	3999	4027
Geomag. aa index	24.8	17.9	24.1	35.8	27.0	25.0	26.1	31.2	27.1	37.9	29.2	22.1	21.8	18.2	19.2	23.8	24.6	25.5	24.8	26.5	43.2	37.9	40.2	40.2
Solar flare	271	413	447	287	325	248	206	123	392	357	262	237	296	154	92	82	167	104	275	217	67	111	--	--
Sunspot number	97	91	84	80	76	74	73	71	69	67	64	60	56	55	52	49	45	41	39	37	35	34	33	33
2800 MHz solar flux	116.7	132.2	122.1	116.8	130.8	145.2	139.1	121.0	142.6	136.4	115.9	112.3	109.3	199.0	93.7	87.0	100.3	95.9	104.8	115.0	99.6	90.4	79.1	79.9

-- Data is not available

TABLE 2

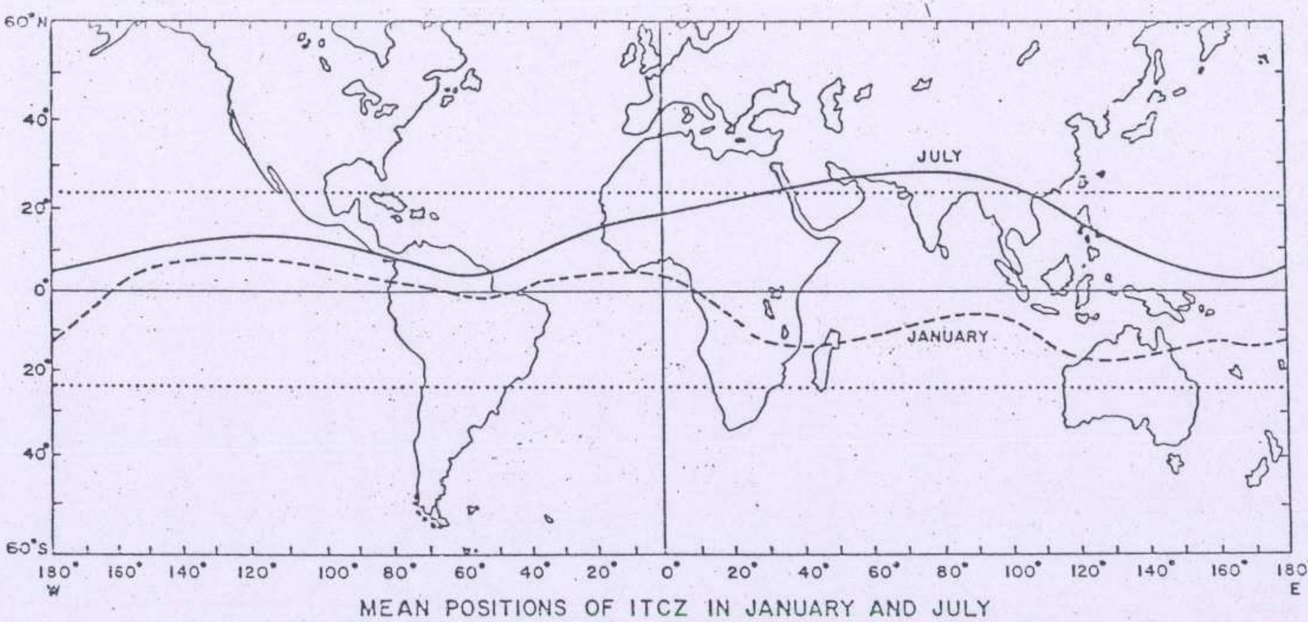
Significant association between the annual mean and seasonal mean circadian rhythm (hourly values) of AMI

Season	Correlation Coefficient with respect to annual rhythm	Significance (%)
WINTER (DJF)	0.70	< 1.0
PREMONSOON (MAM)	0.72	< 1.0
MONSOON (JJA)	0.52	< 1.0
POSTMONSOON (SON)	0.73	< 1.0

TABLE 3

Significant associations between AMI cases and meteorological and solar geophysical parameters during the 2-year period June 92 to May 94

Parameter: Monthly total	Parameter: Month to month variation of mean	No.	Correlation (%)	Significance
AMI cases	surface pressure	23	0.44	< 2.5
"	cosmic ray index	23	0.46	< 2.5
"	solar flare counts	21	0.61	< .05
"	surface pressure	11	0.57	< 5.0
Monthly total AMI	Monthly total solar flare counts	22	-0.49	1.0



(adapted from Riehl, 1979)

Figure 1: Locations of ITCZ during January and July

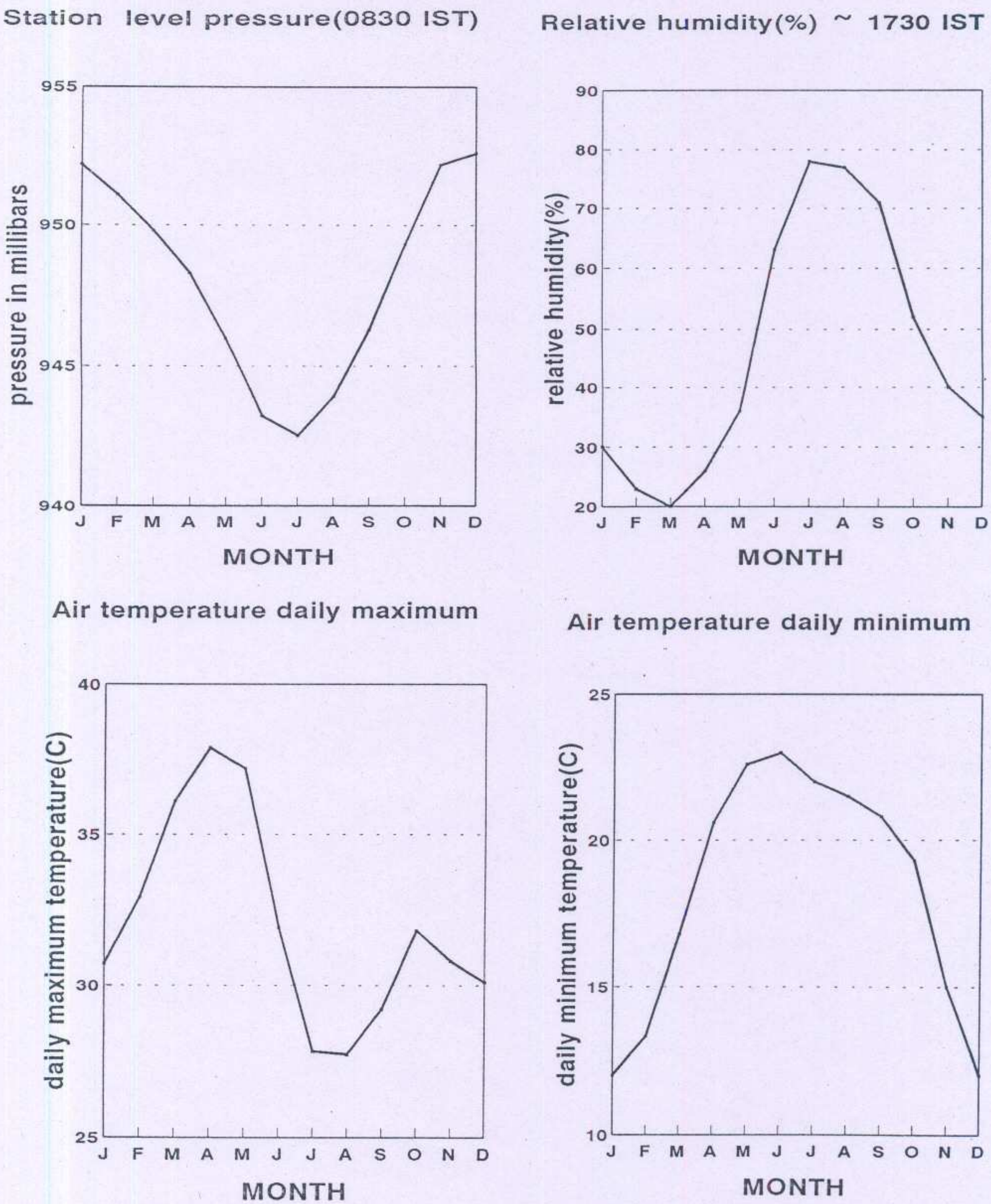


Figure 2: Climatological normals (1931-1960) for meteorological parameters

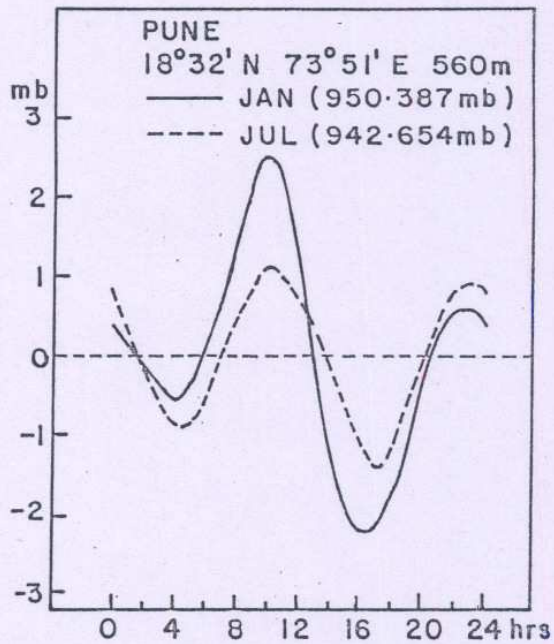


Figure 3: Semidiurnal surface pressure oscillation at Pune, India

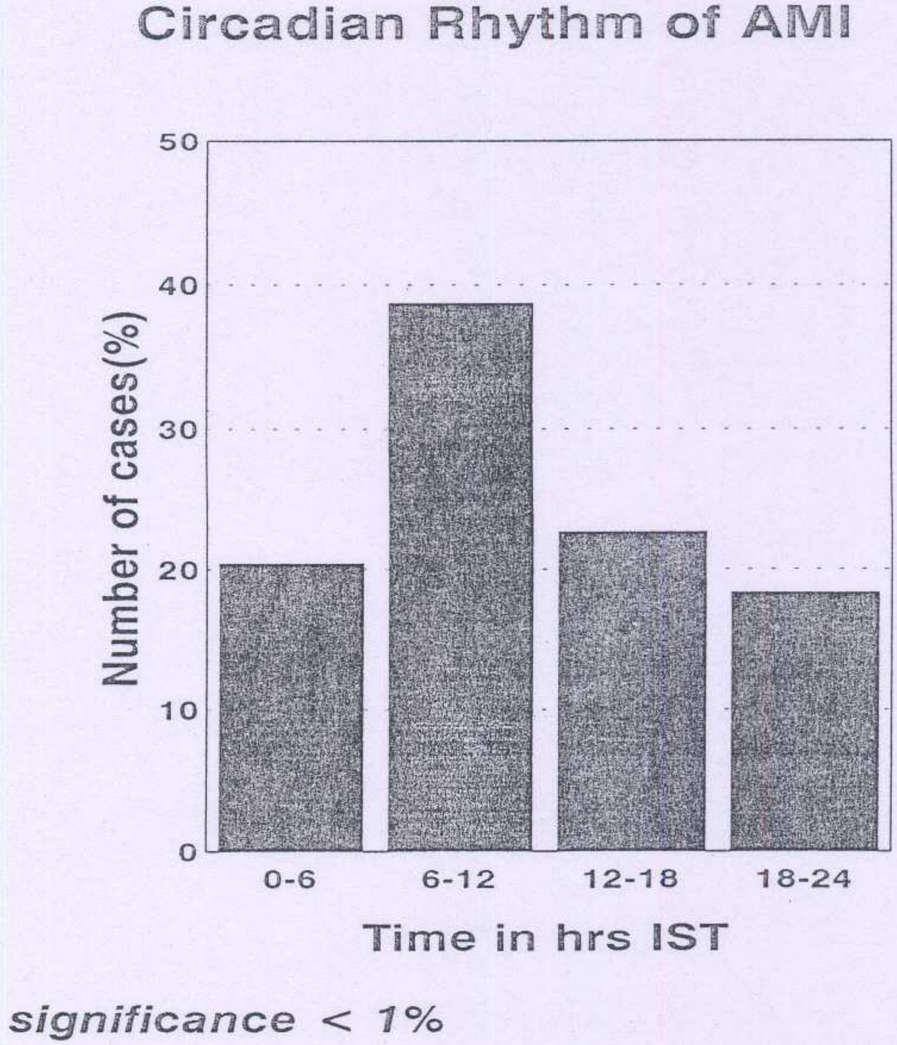
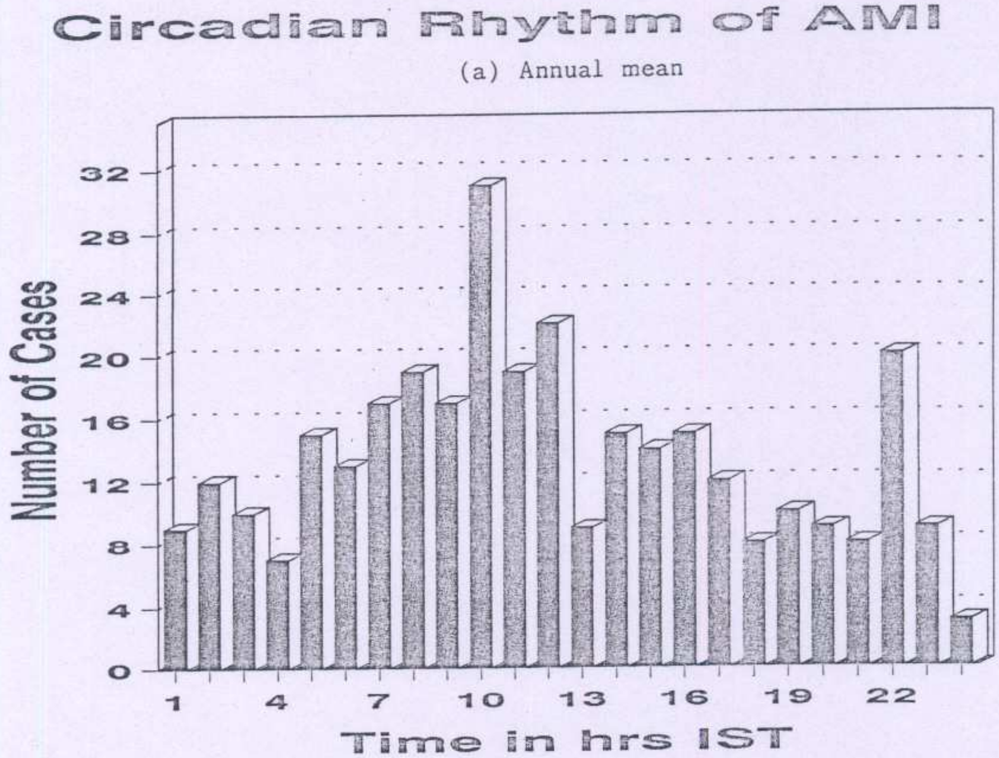
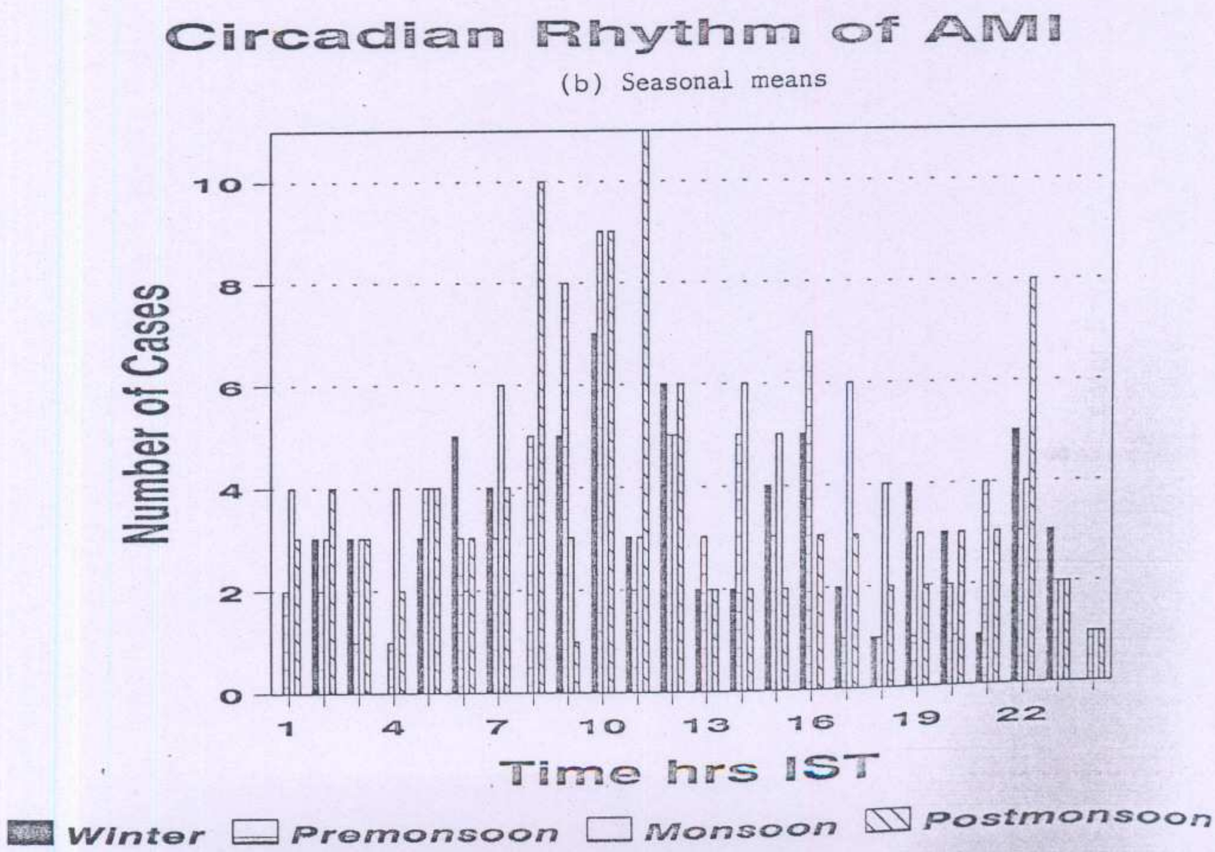


Figure 4: Circadian rhythm of AMI - four quarters of the day

Figure 5: Circadian rhythm of AMI - hour to hour variation



(a) Annual mean



(b) Seasonal means

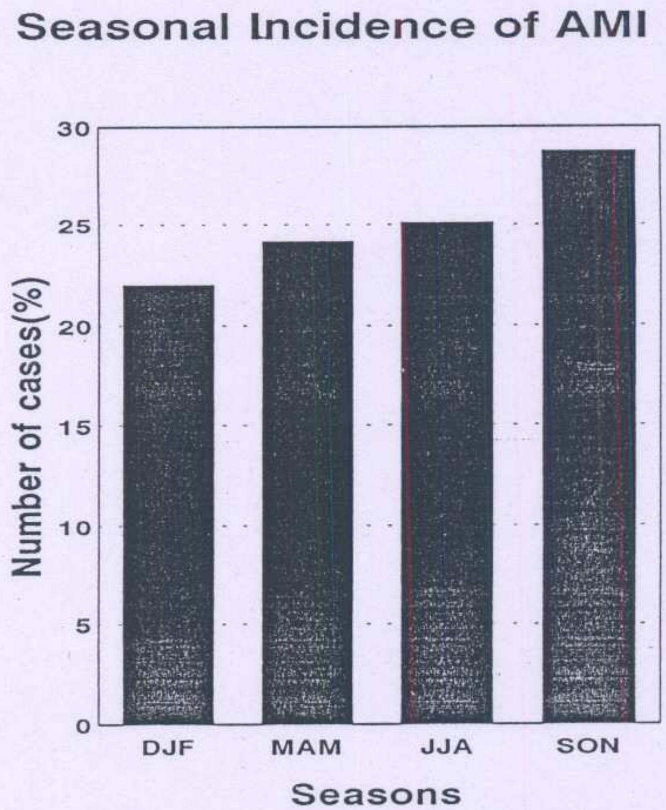


Figure 6: Seasonal variation of AMI

Figure 7: AMI and month to month variation of meteorological parameters

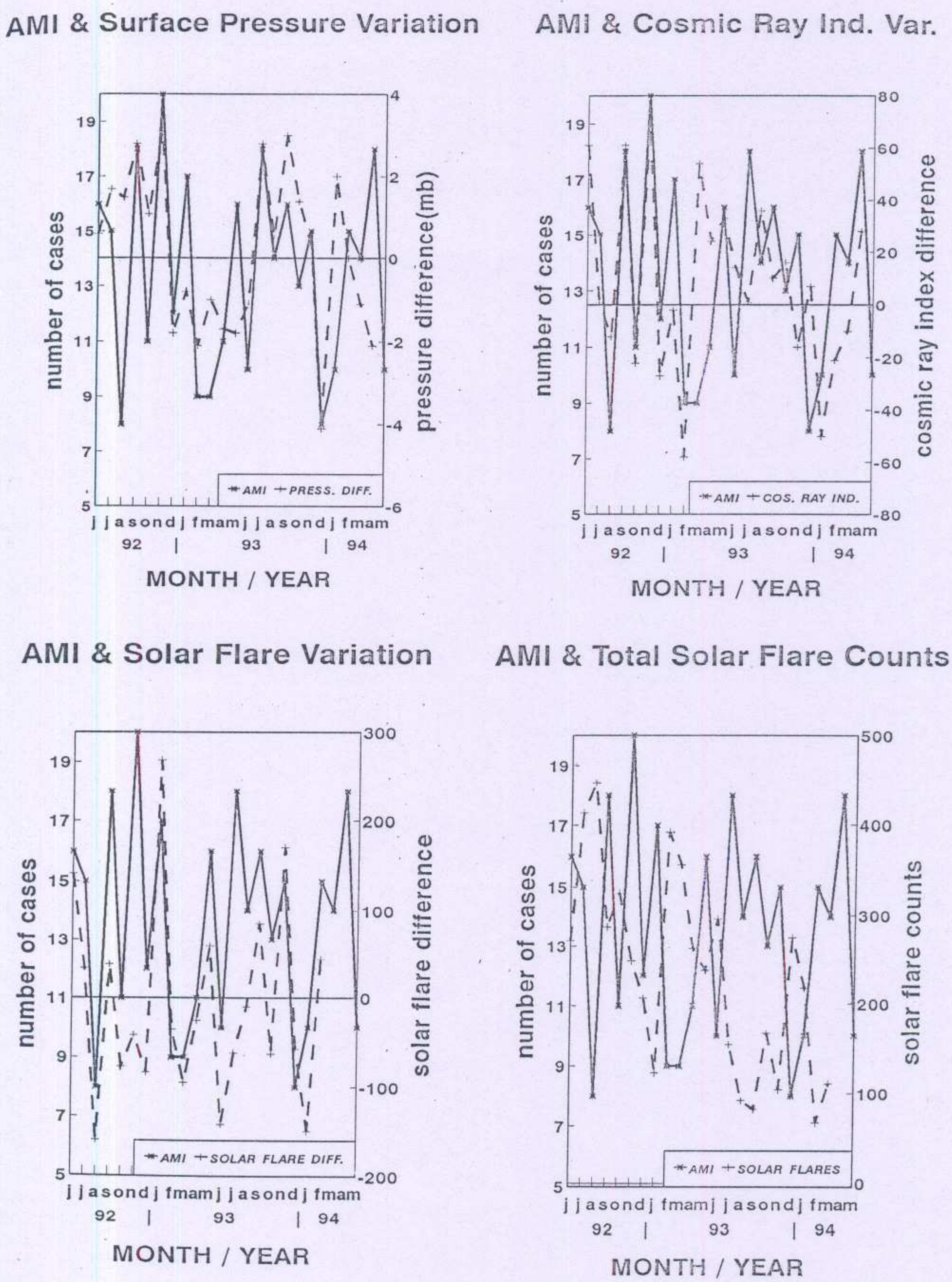


Figure 8: AMI and phases of moon