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CHRONOMES OF OXYGEN SATURATION AND HEART RATE IN HEALTH AND AFTER CORONARY ARTERY BYPASS GRAFTING

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A b s t r a c t

Interventions such as coronary artery bypass grafting (CABG) can be associated with important changes in heart rate (HR) variability as well as with a reduced oxygen saturation (SaO_2). The non-invasive monitoring of HR and SaO_2 can assess such changes sufficiently rapidly to provide guidance for any needed action such as oxygen treatment.

K e y w o r d s

heart rate variability, oxygen saturation, coronary artery bypass grafting

INTRODUCTION

A reduced heart rate variability (HRV) has been associated with a heightened risk of coronary artery disease (*1-3*). Exercise after a myocardial infarction has been shown to improve the patient's prognosis and to bring about an increase in HRV (*4*). HRV has also been reported to be decreased after CABG *(5*). Changes in the about-daily (circadian), about half-weekly (circasemiseptan) and about-weekly (circaseptan) components of different endpoints of HRV, including complexity, have been observed after CABG in the patient studied herein, *Figs. 1* and *2* (*6-8*). Against this background, the time structures (chronomes) of heart rate (HR) and oxygen saturation (SaO_2) are here assessed during the patient's recovery from a quadruple CABG operation and compared with similar records obtained in clinical health on two other volunteers.

SUBJECTS AND METHODS

A 78-year-old man (FH) with a history of coronary artery disease who underwent a quadruple CABG on 29 Oct 1997 monitored his HR and SaO_2 with an ambulatory oximeter (8500M) from Nonin Medical Inc. (Plymouth, MN, USA). For several days, starting on 29 Nov 1997, data were

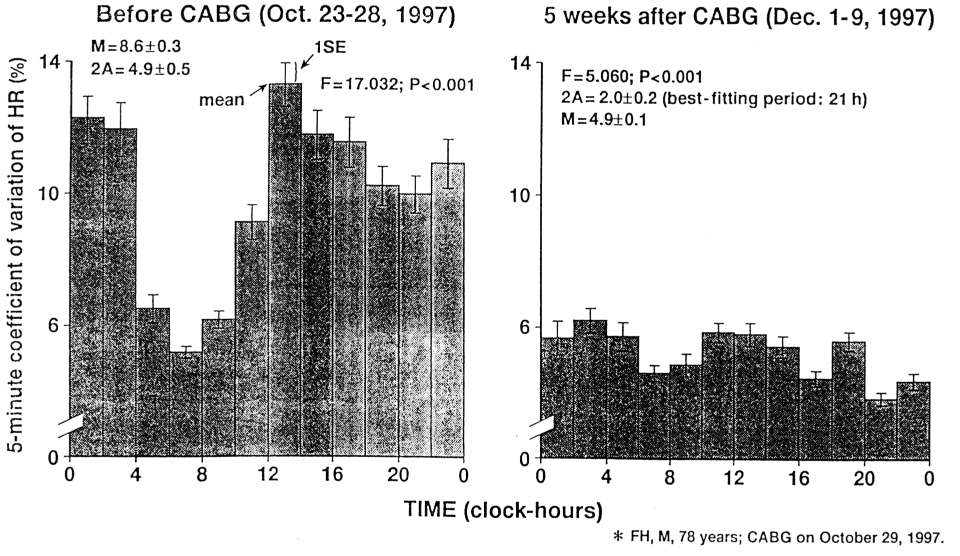

Fig. 1.
Decrease in heart rate variability at 5 weeks following coronary artery bypass grafting (CABG)*.

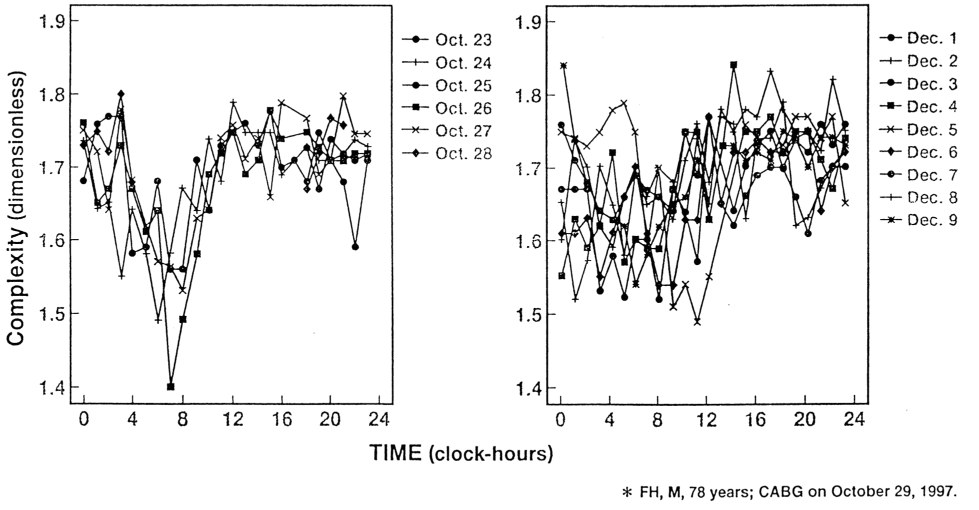

Fig. 2.
Circadian pattern of heart rate complexity before (left) and 5 weeks after (right) coronary artery bypass grafting (CABG)*.

recorded at 4-sec intervals for a few minutes or up to a few hours, at intervals to cover the 24-hour scale. Two clinically healthy women, aged 48 (GC) and 75 (OS) years, were controls. Data stored in the oximeter were retrieved using software by Profax Associates (California) and analyzed by chronobiologic methods (*9, 10*). The original data were binned over 5-min spans prior to analysis by least-squares spectra. During monitoring spans of 1 hour or longer, successive 5-min least squares spectra were averaged to assess the slope of the 1/*f* spectral behavior. The mean and standard deviation were also computed for each 5-min span and analyzed by cosinor (*11*) to assess their circadian and ultradian variation.

RESULTS

Between 29 Nov and 2 Dec 1997, FH contributed data covering 98 spans of 5 min, including two continuous monitoring spans of 100 and 235 min on 29 Nov (from 21:42 to 23:22) and on 30 Nov (from 01:55 to 05:45), respectively. Least squares spectra over consecutive 5-min intervals were averaged and the amplitudes plotted as a function of frequency (from one to 30 cycles per 5 min), using a log-log scale, as shown in *Figs. 3 and 4*. In order to assess the 1/*f* behavior, the log (amplitude) was linearly regressed with respect to log (frequency). For SaO_2, the slope of this regression line was estimated to be -0.55 ± 0.03 on 29 Nov and -0.68 ± 0.03 on 30 Nov. For HR, the corresponding slope estimates were -0.42 ± 0.06 and -0.57 ± 0.05, respectively.

A 1/*f* behavior of SaO_2 and HR was also demonstrable for GC, who provided 7 monitoring spans of about 1 hour or longer. Slopes ranged from -0.42 ± 0.04 to -0.74 ± 0.04 for SaO_2 and from -0.56 ± 0.04 to -0.73 ± 0.07 for HR. As shown in *Fig. 5*, the slope of the log spectrum is circadian stage-dependent ($P<0.05$), being steeper by night than by day.

Overall, least squares spectra were also computed on the series of 98 mean values and standard deviations (SD), computed over 5-min spans for HR and SaO_2 provided by FH, and for similar series of 120 and 121 corresponding values provided by GC and OS, respectively. Prominent ultradian components with periods of about 3.4 and 1.7 hours were thus detected for both variables in addition to the circadian rhythm. For GC and OS, HR peaked around 16:15, as it usually does in adults following a schedule of activity by day and rest/sleep by night, but for FH, HR peaked around 03:20. A circadian variation of SaO_2 was not detected for FH, whereas for GC and OS it was statistically significant, with a peak around 14:50.

DISCUSSION AND CONCLUSION

The prominent ultradian components found in this study are in keeping with similar findings made in a clinically healthy woman using an ambulatory monitor from the Vitalog company (*12*) and are likely associated with the REM cycle. FH showed much lower values of SaO_2 as compared to GC and OS, prompting the use of palliative oxygen treatment. The 8500M ambulatory oximeter from Nonin

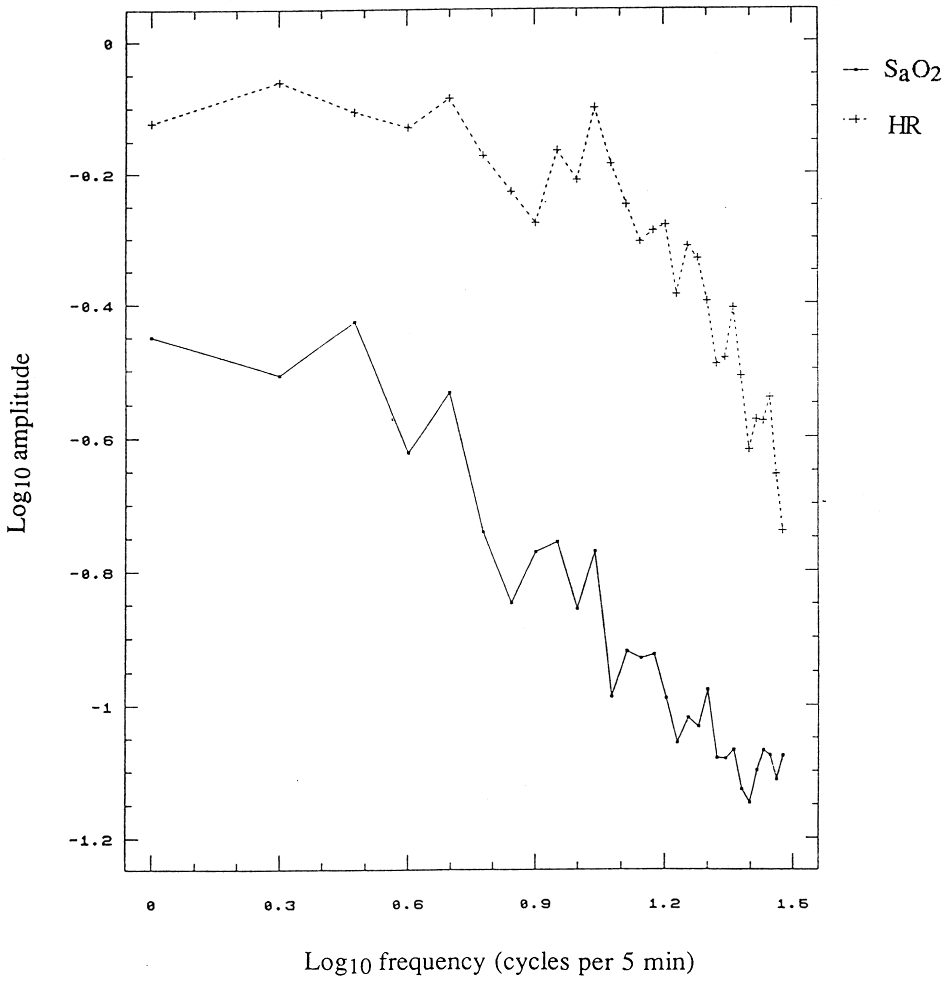

Fig. 3.
Spectra of oxygen saturation (S_aO_2) and heart rate (HR) FH (M, 78y) after cardiac bypass operation.

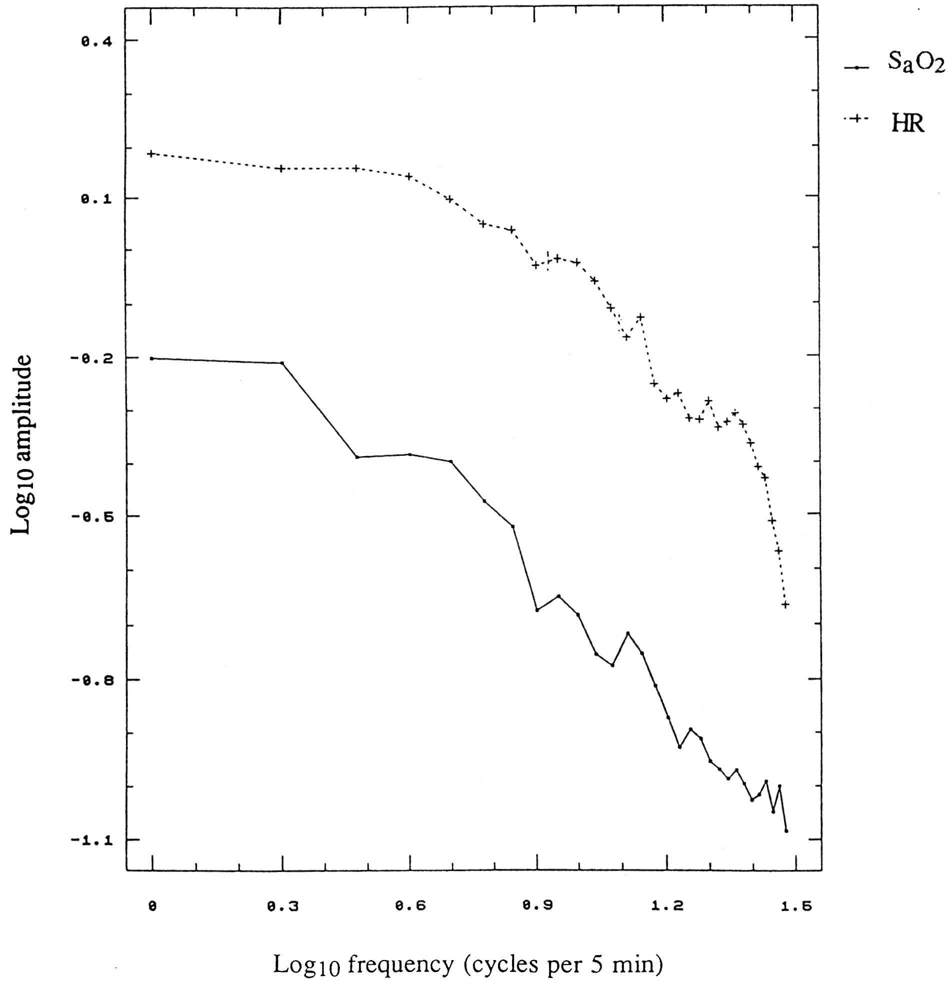

Fig. 4.
Spectra of oxygen saturation (S_aO_2) and heart rate (HR) FH (M, 78y) after cardiac bypass operation.

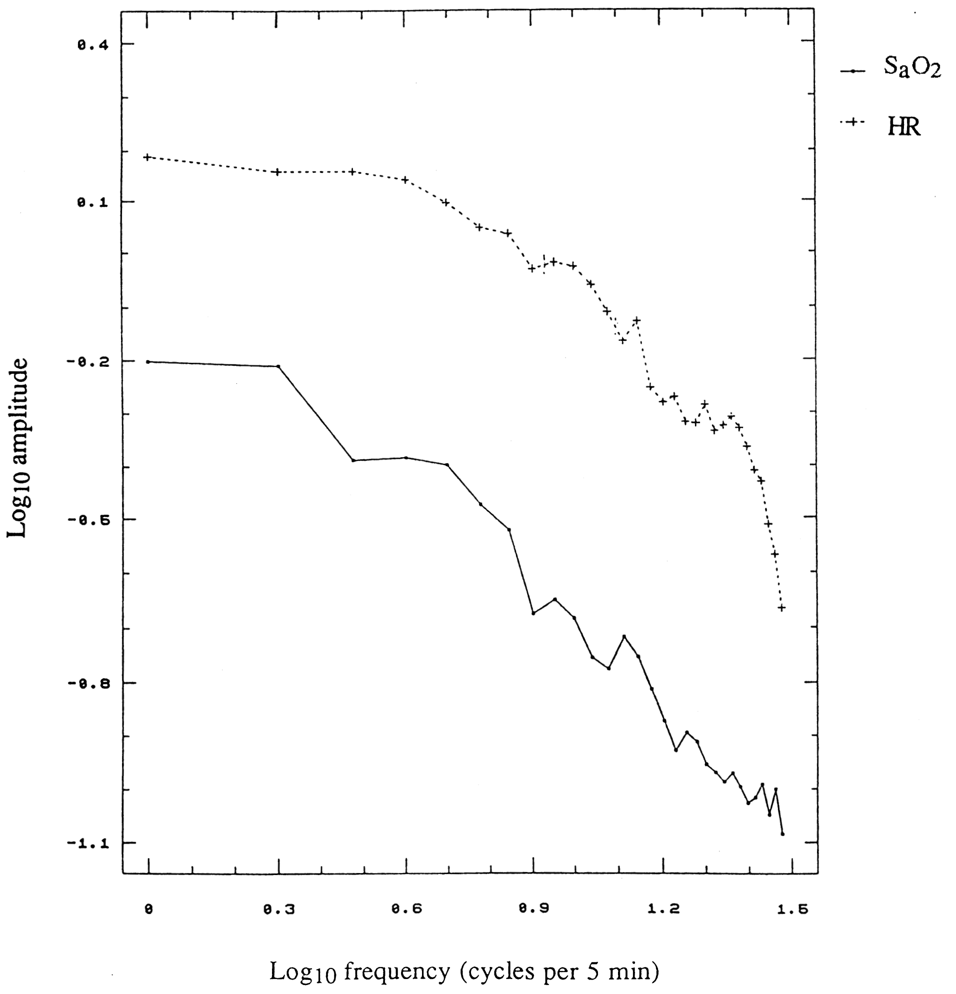

Fig. 5.
Circadian stage dependence of 1/f behavior of oxygen saturation (S_aO_2) and heart rate (HR) of clinically healthy woman (GC, 48y).

is small and easy to use. When combined with chronobiologic analyses, it proves useful for the surveillance of patients after CABG who may require oxygen treatment and who may undergo chronome alterations of several HRV endpoints. Further study of the latter on a longitudinal basis may provide useful clinical information concerning the occurrence of any complications.

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CHRONOMY KYSLÍKOVÉ SATURACE A TEPOVÉ FREKVENCE U ZDRAVÉHO ČLOVĚKA A PO TRANSPLANTACI KORONÁRNÍHO ARTERIÁLNÍHO ŠTĚPU

S o u h r n

Intervence, jako je operace štěpu bypassu koronární artérie, může být spojena se značnými změnami variability srdeční frekvence a se sníženou kyslíkovou saturací. Neinvazivní monitorování srdeční frekvence a kyslíkové saturace může zjistit takové změny dostatečně rychle, aby mohla být zahájena léčba kyslíkem.

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