EE3518 RESPIRATORY AND CARDIOVASCULAR MEASUREMENT
Lecture 2 – Heart rate variability analysis 2

Clinical findings/applications of HRV

HRV has been the subject of numerous clinical studies investigating a wide spectrum of diseases and clinical conditions. There is evidence that HRV can be used to diagnose many clinical pathologies, and in some cases HRV is more sensitive than other techniques, providing a viable method of screening patients in whom no other symptoms have developed.

HRV in cardiological disease assessment

There is strong evidence that HRV analysis has direct application to one particular clinical scenario: depressed HRV can be used as a predictor of risk after acute myocardial infarction. Depressed HRV is a powerful predictor of mortality and of arrhythmic complications (e.g. symptomatic sustained ventricular tachycardia) in patients following acute MI.

The above graph shows the cumulative survival of patients after MI. The curves show survival of patients stratified into three groups according to 24-h SDNN values with cut-off points of 50 and 100 ms.

The predictive value of HRV is independent of other factors established for post-infarction risk stratification, such as depressed left ventricular ejection fraction, increased ventricular ectopic activity, and presence of late potentials. For prediction of all-cause mortality, the value of HRV is similar to that of left ventricular ejection fraction, but HRV is superior to left ventricular ejection fraction in predicting arrhythmic events (sudden cardiac death and ventricular tachycardia). This permits speculation that HRV is a stronger predictor of arrhythmic mortality rather than non-arrhythmic mortality.

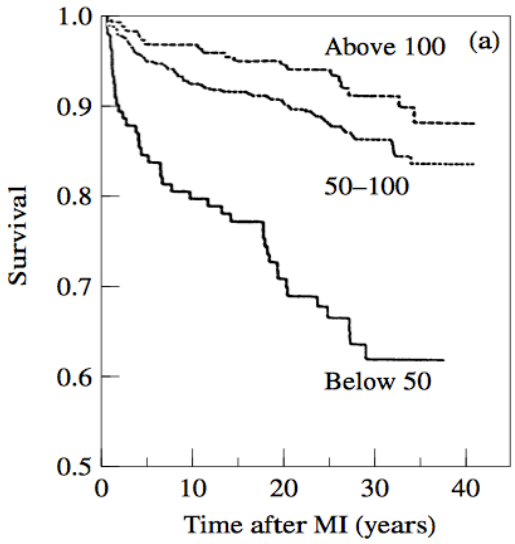

Fig: *Summary of HRV studies in cardiological diseases other than myocardial infarction*

Table: *HRV in non-cardiological pathologies*

Pathology	Reference	Study Population	Method	Clinical Finding
Hypertension	Guzzetti 1991	49 hypertensive 30 normals	Spectral AR	Increased LF found in hypertensives as compared to normals with blunting of circadian patterns
Hypertension	Langewitz 1994	41 borderline hypertensive, 34 hypertensive 54 normals	Spectral FFT	Reduced parasympathetic in hypertensive patients
Congestive heart failure	Saul 1988	25 chronic CHF NYHA III, IV 21 normals	Spectral Blackman–Turkey 15 min acquisition	Decrease in spectral power all frequencies, especially >0·04 Hz in CHF patients
Congestive heart failure	Binkley 1991	10 dilated cardiomyopathy (EF 14 to 40%) 10 normals	Spectral FFT 4 min supine acquisition	Decrease in high frequency power (>0·1 Hz) in CHF
Heart transplantation	Alexopoulos 1988	19 transplant 10 normals	Time–domain 24 h-Holter	Increased LF/HF
Heart transplantation	Sands 1989	17 transplant 6 normals	Spectral FFT 15 min supine acquisition	HRV from 0·02 to 1·0 Hz — 90% reduced
Chronic mitral regurgitation	Stein 1993	38 chronic mitral regurgitation	Spectral FFT Time-domain 24 h-Holter	HR and measures of ultralow frequency by SDANN correlated with ventricular performance and predicted clinical events
Mitral valve prolapse	Marangoni 1993	39 female mitral valve prolapse 24 female controls	Spectral AR 10 min supine acquisition	MVP patients had reduced HF

HRV and the nervous system

Disorders of the central and peripheral nervous system have effects on HRV. The vagally and sympathetically mediated fluctuations in HR may be independently affected by some disorders. All normal cyclic changes in HR are reduced in the presence of severe brain damage and depression . HRV was less accurate than the Glasgow Coma Scale in predicting outcome. But it was easily accessible and may provide information about the patient's neurologic status. There are conflicting reports about the HRV and major depression. It has been proved that, in physically healthy depressed adults the HRV does and does not vary from healthy subjects.

HRV in diabetes

In neuropathy associated with diabetes mellitus, characterized by alteration of small nerve fibres, a reduction in time–domain parameters of HRV seems not only to carry negative prognostic value but also to precede the clinical expression of autonomic neuropathy.

Although traditional measures of autonomic function are able to document the presence of neuropathy, in general they are only abnormal when there is severe symptomatology. Thus by the time changes in function were evident, the natural course of autonomic neuropathy was well established. Decreased beat-to-beat variability during deep breathing in diabetic neuropathy was first reported by Wheeler and Watkins and confirmed by many others. In studies comparing cardiac autonomic function tests and HRV indices (based on both short (5- min) and 24-h ECG recordings), show that, in diabetic patients without abnormal function tests, HRV was lowered. It was concluded that cardiac (parasympathetic) autonomic activity was diminished in diabetic patients before clinical symptoms of neuropathy become evident.

HRV in renal failure

In patients with renal failure, autonomic function tests have been done, followed by HRV indices and spectral analysis of HR. Although autonomic function tests revealed predominant impairment of the PNS, spectral analysis exhibited a strong reduction in the HR power spectrum at all frequency ranges, both sympathetically and parasympathetically. The relationship between HRV parameters and electrolyte ion concentrations in both pre- and post-dialysis was analysed. The 5-min HRV of 20 chronic renal failure (CRF) patients were analyzed. Results revealed that calcium is negatively correlated to the mean of RR intervals and normalized HF power after hemodialysis

HRV and gender, age

It is proved that, the HRV depends on the age and sex also. The HRV was more in the physically active young and old women. It was proved by Emese et al. that the alert new borns have lower HR variation in the boys than in the case of girls. The HR variation for healthy subjects from 20 to 70 years was studied by Bonnemeir et al. and found that the HRV decreases with age and variation is more in the case of female than men.

HRV and smoking

Studies have shown that smokers have increased sympathetic and reduced vagal activity as measured by HRV analysis. Smoking reduces the HRV. One of the mechanisms by which smoking impairs the cardiovascular function is its effect on ANS control. Altered cardiac autonomic function, assessed by decrements in HRV, is associated with acute exposure to environmental tobacco smoke (ETS) and may be part of the pathophysiologic mechanisms linking ETS exposure and increased cardiac vulnerability. Recently Zeskind and Gingras have shown that cigarette exposed fetuses have lower HRV and disrupted temporal organization of autonomic regulation before effects of parturition, postnatal adaptation, and possible nicotine withdrawal contributed to differences in infant neurobehavioral function.

HRV and alcohol

HRV reduces with the acute ingestion of alcohol, suggesting sympathetic activation and/or parasympathetic withdrawal. Malpas et al. have demonstrated vagal neuropathy in men with chronic alcohol dependence using 24 h HRV analysis. Ryan et al. have previously reported a strong positive association between average day time and nighttime HR measured during 24 h ambulatory BP monitoring and usual alcohol intake. ECG indices of vagal activity have been reported to have

significantly lower indices of cardiac vagal nerve activity than normal volunteers, in acute alcoholic subjects

HRV and sleep

Studies suggest that mechanisms involving electroencephalographic desynchronization and/or conscious states of the brain are reflected in the fractal component of HRV. Compared to stages 2 and 4 non-REM sleep, the total spectrum power was significantly higher in REM sleep and its value gradually increased in the course of each REM cycle. The value of the VLF component (reflects slow regulatory mechanisms, e.g., thermoregulation) was significantly higher in REM sleep than in stages 2 and 4 of non-REM sleep. The LF spectral component (linked to the sympathetic modulation) was significantly higher in REM sleep than in stages 2 and 4 non-REM sleep. Patients with sleep apnoea tend to have a spectral peak lying between 0.01 and 0.05 cycles/beat, with the width of the peak indicating variability in the recurrence rate of the apnoea. In most of the subjects, the frequency spectrum immediately below the apnoea peak was relatively flat. The first visual analysis of the single computed spectrum from each subject led to a correct classification score of 28/30 (93%). Gates et al. suggested that long-lasting alterations existed in autonomic function in snoring subjects.