AUTONOMIC NERVOUS SYSTEM ACTIVITY ASSESSMENT USING PUPILLOMETRY AND HEART RATE VARIABILITY DURING INTRADIALYTIC EXERCISE TRAINING IN HEMODIALYSIS PATIENTS

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INTRODUCTION - AIMS

Cardiac autonomic nervous system (ANS) dysfunction is a common feature in patients receiving hemodialysis (HD) therapy[1]. Until today, spectral analysis of heart rate variability (HRV) is the most commonly used noninvasive method for the assessment of ANS activity. Pupillometry is a valid and low-cost method for the evaluation of ANS activity which reveals the sub-clinical defects in autonomic function of various diseases but also it has been proposed to be used as a complementary tool in the evaluation of cardiac autonomic function[2]. Decreased HRV due to dysfunction of the cardiac autonomic function is a known complication of HD patients and is associated with an increased risk of ventricular arrhythmias and sudden death[3]. However, the effect of HD on autonomic regulation of pupillary light reflex is not known. Furthermore, there are limited data available regarding alterations in HRV and pupillary light reflex during intradialytic exercise or without in HD patients. **The aim of this study was to investigate and compare the hemodynamic changes and responses of ANS function in HD patients using pupillometry and HRV parameters during HD treatment under resting conditions and during a single bout of intradialytic exercise.**

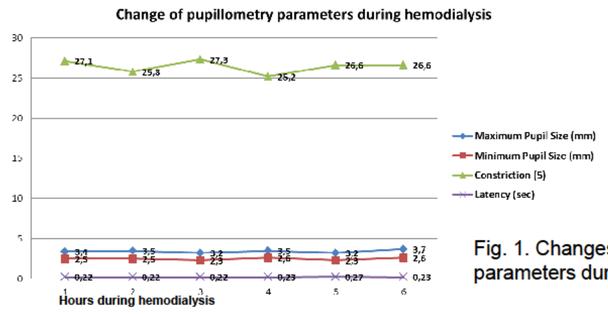


Fig. 1. Changes among pupillometric parameters during hemodialysis

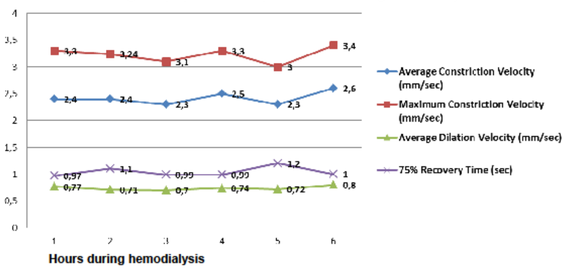


Fig. 2. Changes among pupillometric parameters during hemodialysis

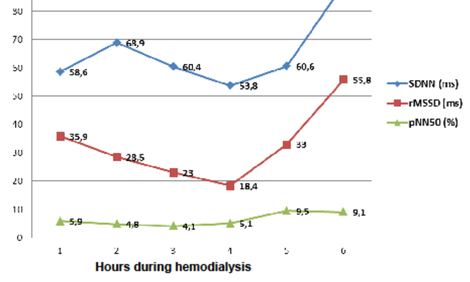


Fig. 3. Changes among HRV parameters during hemodialysis

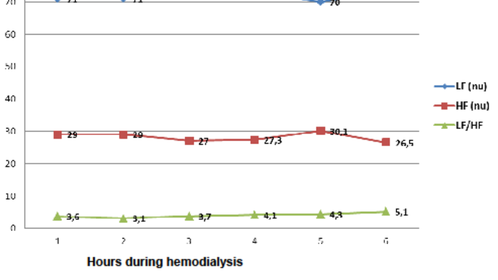


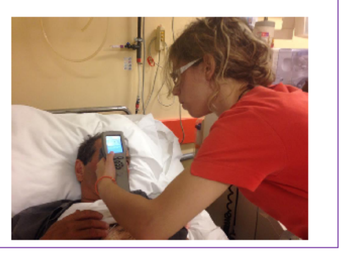
Fig. 4. Changes among HRV parameters during hemodialysis

METHODS

Sixteen chronic HD patients (54 ± 16.9 years) underwent pupillometric measurements using a portable handheld pupil measuring device before, every hour and after a HD session. Measurements took place during HD under two different conditions:

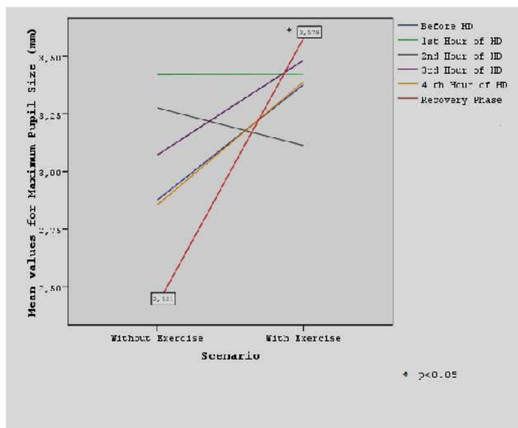
- ✓ the first condition included a normal HD session (rest)
- ✓ the second condition included a single bout of a 45 min of intradialytic exercise

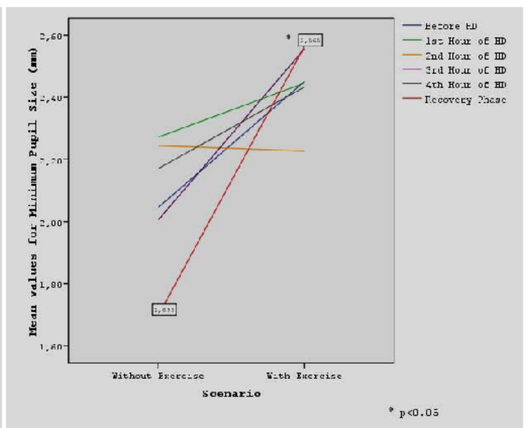
The pupillometric indices included: 1. maximum and minimum pupil size (mm), 2. Constriction (%), latency (sec), average and maximum constriction velocity and 75% recovery time. Before, every hour and after the HD session standard HRV analysis was performed using a Polar monitor.



RESULTS

Differences in pupillometric results between the two scenarios





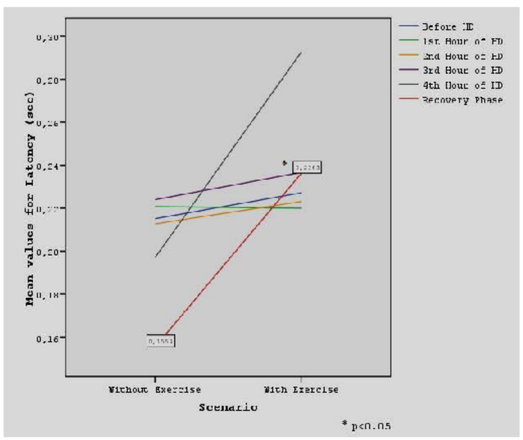


Table 1. Pearson's correlation coefficients between pupillometric and HRV parameters before hemodialysis

	Maximum Pupil Size (mm)	Minimum Pupil Size (mm)	Constriction (%)	Latency (sec)	Average Constriction Velocity (mm/sec)	Maximum Constriction Velocity (mm/sec)	Average Dilation Velocity (mm/sec)	75% Recovery Time (sec)
SDNN (ms)	-0.033	0.072	-0.102	-0.032	-0.111	-0.124	0.119	-0.276
rMSSD (ms)	-0.064	0.051	-0.192	0.071	-0.162	-0.214	0.032	-0.283
pNN50 (%)	-0.028	0.220	-0.252	0.145	-0.104	-0.244	-0.053	-0.130
LF (nu)	0.357	-0.042	0.595*	-0.350	0.418	0.608	0.487	0.148
HF (nu)	-0.357	0.042	-0.595*	0.350	-0.418	-0.608	-0.487	-0.148
LF/HF	0.607*	0.271	0.566*	-0.247	0.648*	0.725	0.754	0.197

*Correlation is significant at the 0.05 level

Table 2. Pearson's correlation coefficients between pupillometric and HRV parameters during the 1st hour of hemodialysis

	Maximum Pupil Size (mm)	Minimum Pupil Size (mm)	Constriction (%)	Latency (sec)	Average Constriction Velocity (mm/sec)	Maximum Constriction Velocity (mm/sec)	Average Dilation Velocity (mm/sec)	75% Recovery Time (sec)
SDNN (ms)	-0.238	-0.312	0.118	0.027	-0.045	-0.013	0.086	-0.290
rMSSD (ms)	-0.289	-0.185	-0.348	-0.131	-0.280	-0.322	0.072	-0.511
pNN50 (%)	-0.023	0.018	-0.143	-0.025	-0.024	-0.094	0.275	-0.204
LF (nu)	0.135	0.109	0.308	0.213	0.319	0.343	0.240	0.253
HF (nu)	-0.135	-0.109	-0.308	-0.213	-0.319	-0.343	-0.240	-0.253
LF/HF	0.203	0.294	0.171	0.172	0.237	0.266	0.170	0.348

*Correlation is significant at the 0.05 level

Table 3. Pearson's correlation coefficients between pupillometric and HRV parameters during intradialytic exercise training

	Maximum Pupil Size (mm)	Minimum Pupil Size (mm)	Constriction (%)	Latency (sec)	Average Constriction Velocity (mm/sec)	Maximum Constriction Velocity (mm/sec)	Average Dilation Velocity (mm/sec)	75% Recovery Time (sec)
SDNN (ms)	0.020	-0.092	0.135	0.139	0.198	0.217	0.242	0.178
rMSSD (ms)	0.015	0,031	-0.027	0.252	0.045	0.086	0.128	0.231
pNN50 (%)	0.080	0.066	-0.057	0.224	0.094	0.150	0.185	0.235
LF (nu)	0.451	0.465	0.175	0.348	0.349	0.382	0.470	-0.094
HF (nu)	-0.451	-0.464	-0.178	-0.350	-0.351	-0.384	-0.471	0.088
LF/HF	0.307	0.317	0.183	0.200	0.256	0.282	0.332	-0.155

*Correlation is significant at the 0.05 level

Table 4. Pearson's correlation coefficients between pupillometric and HRV parameters after intradialytic exercise training

	Maximum Pupil Size (mm)	Minimum Pupil Size (mm)	Constriction (%)	Latency (sec)	Average Constriction Velocity (mm/sec)	Maximum Constriction Velocity (mm/sec)	Average Dilation Velocity (mm/sec)	75% Recovery Time (sec)
SDNN (ms)	0.220	0.036	0.444	-0.281	0.414	0.409	0.452	0.181
rMSSD (ms)	-0.270	-0,033	-0.559*	0.172	-0.608*	-0.606*	-0.538*	-0.112
pNN50 (%)	-0.195	0.032	-0.558*	0.201	-0.584*	-0.586*	-0.597*	-0.020
LF (nu)	0.105	-0.033	0.554*	-0.412	0.575*	0.598*	0.662*	0.109
HF (nu)	-0.105	0.033	-0.554*	0.412	-0.575	-0.598*	-0.662*	-0.109
LF/HF	0.197	0.022	0.572*	-0.452	0.595*	0.621*	0.561*	0.296

*Correlation is significant at the 0.05 level

Table 5. Pearson's correlation coefficients between pupillometric and HRV parameters during the 4th hour of hemodialysis

	Maximum Pupil Size (mm)	Minimum Pupil Size (mm)	Constriction (%)	Latency (sec)	Average Constriction Velocity (mm/sec)	Maximum Constriction Velocity (mm/sec)	Average Dilation Velocity (mm/sec)	75% Recovery Time (sec)
SDNN (ms)	-0.087	-0.043	-0.236	0.133	-0.213	-0.317	0.029	-0.002
rMSSD (ms)	-0.268	-0,067	-0.555*	-0.122	-0.534*	-0.477	-0.221	-0.430
pNN50 (%)	-0.421	-0.212	-0.691*	-0.135	-0.711*	-0.615*	-0.502	-0.453
LF (nu)	0.227	-0.065	0.621*	0.199	0.576*	0.457	0.263	0.512
HF (nu)	-0.227	0.065	-0.621*	-0.199	-0.576*	-0.457	-0.263	-0.512
LF/HF	0.369	0.176	-0.452*	0.196	0.490	0.413	0.204	0.416

*Correlation is significant at the 0.05 level

Table 6. Pearson's correlation coefficients between pupillometric and HRV parameters after hemodialysis

	Maximum Pupil Size (mm)	Minimum Pupil Size (mm)	Constriction (%)	Latency (sec)	Average Constriction Velocity (mm/sec)	Maximum Constriction Velocity (mm/sec)	Average Dilation Velocity (mm/sec)	75% Recovery Time (sec)
SDNN (ms)	0.123	0.226	-0.061	-0.437	0.138	0.111	0.555	-0.311
rMSSD (ms)	0.069	0,242	-0.191	-0.403	0.008	-0.017	0.450	-0.331
pNN50 (%)	0.295	0.439	-0.155	0.170	0.058	0.038	0.049	0.059
LF (nu)	0.235	-0.123	0.756*	-0.259	0.561*	0.569*	0.364	0.300
HF (nu)	-0.235	0.123	-0.756*	0.259	-0.561*	-0.569*	-0.364	-0.300
LF/HF	-0.109	-0.354	0.537*	-0.189	0.176	0.206	-0.046	0.561*

*Correlation is significant at the 0.05 level

RESULTS

No significant changes were observed in neither of the pupillometric and the HRV values before, for each hour and after the HD session in both scenarios. Only maximum and minimum pupil size and latency at the recovery phase (after the end of HD) differ between the two scenarios. Specifically during the day with intradialytic exercise patients had shown positive changes in maximum and minimum pupil size by 54.1% (p=0.033) and by 53.6% (p=0.028), respectively and latency by 60% (p=0.030) compared to the day without exercise. Moreover, HRV parameters were significantly correlated with pupillometric parameters at rest and immediately after the single bout of intradialytic exercise

CONCLUSIONS

ANS activity did not alter during the course of the HD therapy in neither of the two scenarios with or without intradialytic exercise. Moreover, some of the pupillometric indices which reflect the sympatho-vagal balance showed positive changes after the exercise event. However, indices of ANS function assessed by the two methods correlated significantly only at rest and after intradialytic exercise. Pupillometry, as a technique seems to be more robust with fewer artifacts compared to HRV especially in studies involving exercise sessions. Pupillometry can be used as a complementary tool in the evaluation of cardiac autonomic dysfunction in HD patients which in fact it could provide additional information for different aspects of the overall ANS

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