Central Hemodynamic Monitoring of Train Drivers in Western Russia

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Introduction

Train drivers are exposed to work-related stressors which contribute to higher rates of cardiovascular disease[1]. No studies have characterized precursors of this effect in Western Russia. This project aims to identify early disturbances and trends in central hemodynamic parameters among young train conductors in order to elucidate patterns of decompensation and identify high-risk groups who may benefit from prophylaxis.

In accordance with current Russian legislation (signed into law in 2011), all individuals applying to become train drivers are subjected to a preliminary medical examination. If arterial hypertension is detected, applicants are unable to pursue work in this profession. Additionally, the Russian government requires drivers to undergo mandatory blood pressure testing before every shift they are operating a train[2].

Hypothesis

Deviations in central hemodynamic parameters including cardiac output (CO), pulse wave velocity (PWV), and systemic vascular resistance (SVR) can occur in isolation prior to the development of clinical elevations in arterial blood pressure.

Research Methods

This study is a retrospective review of hemodynamic parameters among train conductors in the Moscow region of the Russian Federation from December 2003 to September 2004.

Originally 179 newly-hired train driver assistants underwent regular hemodynamic studies before each shift. Of this number, 11 drivers were excluded from the study due to an insufficient number of measurements or length of participation, leaving 168 subjects. All participants were men between the ages of 18 and 34 years. Men with pre-existing hypertension were excluded from the study.

Subjects underwent regular hemodynamic monitoring within this period before every train departure. Automated oscillometric methods were used to obtain resting measurements of blood pressure, cardiac output, pulse wave velocity, and systemic vascular resistance with the device “KAP CG osm – ‘Globus’”.

Statistical analysis was performed using Excel and PSPP version 1.2.0-g0fb4db. PSPP is an open-source software program which functions like the proprietary software SPPS.

Hemodynamic parameters were routinely monitored using a specialized compression cuff before every train trip.
“Globus” oscillometric methods were initially developed as part of the Soviet space program.

Results

Descriptive Statistics
(Individual Averages, N = 168)

	M	SD	CV	95% CI
1. Systolic Blood Pressure (mmHg)	117.76	7.06	7.1%	[118.83, 116.69]
2. Diastolic Blood Pressure (mmHg)	69.36	7.25	8.2%	[70.46, 68.27]
3. Heart Rate (bpm)	82.84	7.42	10.6%	[83.96, 81.72]
4. Cardiac Output (L/min)	5.51	.42	8.2%	[5.57, 5.44]
5. Pulse Wave Velocity (cm/sec)	921.32	46.99	9.6%	[928.42, 914.21]
6. Systemic Vascular Resistance (dyn·cm-5/sec)	1174.70	84.06	6.8%	[1187.41, 1161.99]

M = mean, SD = standard deviation, CV = coefficient of variation, CI = confidence interval.
Reference ranges: systolic blood pressure 100-139 mmHg, diastolic blood pressure 60-89 mmHg, heart rate 60-80 bpm, pulse wave velocity 600-1000 cm/sec.

Table of Correlations
(All Measurements, N = 8674)

	SBP	DBP	HR	CO	PWV	SVR
SBP	--					
DBP	.3***	--				
HR	.03**	.23***	--			
CO	.71***	.19***	.16***	--		
PWV	.48***	-.24***	-.12***	.55***	--	
SVR	-.21***	.72***	.14***	-.39***	-.38***	--

*Asterisks indicate statistical significance. *p < .05, **p < .01, ***p < .001 Two-tailed test.*

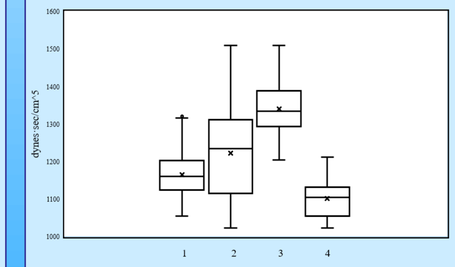
Average Measurements by Blood Pressure Group

	Sys BP	Dia BP	HR	CO	PWV	SVR
Hypotension	111.88	57.38***	79.38	5.28	931.00	1081.00***
Normotension	115.63	67.74	82.53	5.42	914.49	1164.53
Hypertension (1-2 stage)	125.10***	76.41***	84.41	5.80***	739.32***	1222.51**
Isolated systolic hypertension	127.07***	68.27	80.47	6.02***	775.80***	1100.80***
Isolated diastolic hypertension	119.55*	82.91***	89.36**	5.43	681.00***	1340.27***

*Asterisks indicate values that significantly differ from normotension (*p < 0.05, **p < 0.01, ***p < 0.001)*

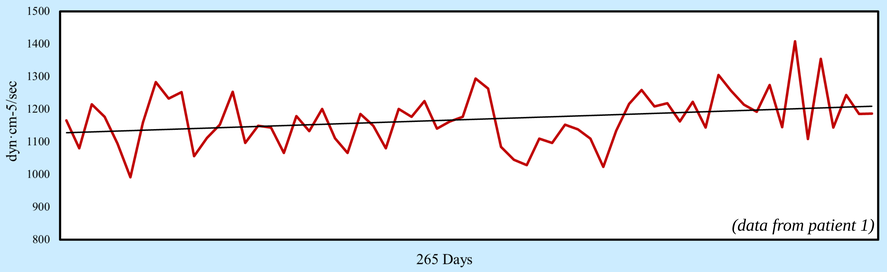
The combined hypertension group showed elevated cardiac output (CO) and systemic vascular resistance (SVR). Individuals with isolated diastolic hypertension group had the highest average heart rate (HR) and SVR.

Average SVR by Blood Pressure Groups



1 = Normotension, 2 = Hypertension, 3 = Isolated Diastolic Hypertension, 4 = Isolated Systolic Hypertension

Systemic Vascular Resistance (SVR) over Time



265 Days

We observed an overall upward trend in SVR for the population sampled when regression coefficients were averaged (M = 0.29, SD ±2.08). Most individuals (99 out of 168, i.e. 59%) showed a positive trend in SVR over time. No other hemodynamic parameter demonstrated a clear trend in aggregate.

Results

The sample was comprised of 168 individuals and 8674 unique measurements; the mean age was 26.2 ± 4.6 years with an average of 52 ± 17 measurements per person over 33.8 ± 8.9 weeks. The average values for each hemodynamic parameter were within normal limits. Across all measurements, heart rate showed the greatest time-independent variation while systolic blood pressure showed the least; coefficients of variation ($\sigma/\bar{x}$) were 10.6% and 6.8% respectively.

Hypertensive episodes were observed in 36.3% of participants (measurements exceeded 139 mmHg for systolic pressure and/or 89 mmHg for diastolic pressure). Hypertensives were defined as individuals whose blood pressure readings exceeded 139/89 mm Hg in at least twice. There were 41 (24.4%) of these participants, of whom 35 were categorized as first-degree hypertension and 6 fell into second-degree hypertension as defined by the European Society of Hypertension[3]. Among hypertensives, the number of participants with isolated systolic and diastolic blood pressure was 15 and 11, respectively. There were 8 (4.76%) hypotensive participants with average arterial pressures (systolic and/or diastolic) below normal limits.

Strong, positive correlations were observed between diastolic blood pressure and systemic vascular resistance ($r = 0.72$, $p < 0.001$), systolic blood pressure and cardiac output ($r = 0.71$, $p < 0.001$) respectively. Older subjects tended to have higher diastolic blood pressure ($r = 0.51$, $p < 0.001$). In aggregate, systolic blood pressure was also positively correlated with age, albeit to a lesser extent ($r = 0.11$, $p < 0.001$). Increasing systemic vascular resistance over time was positively correlated with decreasing systolic blood pressure and increasing diastolic blood pressure.

Discussion

This sample had higher rates of hypertension than the general population of United States adults in the same age group; hypertension has a reported incidence of 9.1% in men between the ages of 20 and 34[4].

In a study of 1277 Mongolian railroad workers, men under the age of thirty had a 16.3% incidence of hypertension; in the 30-39 year old age group, the incidence increased markedly to 47.2%[5]. An older (ages 30-59) population of 600 Siberian railroad workers had an incidence of 50.2%, with 15% in the first stage and 35% in the second stage of severity[6]. The sample seems to be consistent with outside samples with some variation. It is clear that hypertension increases with age and the length of time spent working as a train driver.

Conclusions

Persistent changes in central hemodynamics can precede the development of clinical arterial hypertension. The results of this study suggest that implementation of early monitoring and prophylactic measures may be beneficial for high-risk individuals. Reviewing central hemodynamic parameters may become a helpful part of standard clinical practice for physicians in the future.

Acknowledgments

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