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A Comparison of Cardiac Surgeon's Stress Level During Off-Pump and On-Pump CABG by Cardiac Variability Indices, A Case-Report

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Abstract

Background: There is still controversy regarding the benefits of off-pump CABG and the stress that these procedures impose on the cardiac surgeon has not been previously studied. We sought to investigate whether off-pump operations are more demanding for the cardiac surgeon compared to the on-pump by evaluating the stress level by the cardiac variability indices.

Methods: The heart rate variability indices, including the low frequency (LF), high frequency (HF), and low frequency/high frequency ratio (LF/HF), as well as heart rate (HR) were recorded throughout 17 on-pump and 16 off-pump coronary artery bypass grafting (CABG) operations for an experienced cardiac surgeon. The operations were divided into six phases to indicate the most important surgical moments, which were subsequently compared between the two types of procedures.

Results: There was a statistically significant difference (P-value<0.0001) in the surgical phases in terms of the LF, HF, LF/HF ratio, and HR. The HF, LF/HF and HR were also statistically significantly different with respect to the two types of surgeries (P-value < 0.01). The LF, however, did not show a statistically significant difference (P-value = 0. 485).

The LF/HF in the off-pump CABGs showed a significant increase during posterior distal anastomosis and it thereafter declined gradually to its base level by the time of proximal anastomosis. The LF/HF in the on-pump CABGs showed an increase at the time of cannulation and cardiopulmonary bypass and it decreased afterwards to its base level by the time of posterior distal anastomosis and remained almost constant until the end of the operation.

Conclusion: Our results indicated that the stress level of the surgeon is higher when performing off-pump operations compared to on-pump procedures; this was manifested by the difference in the heart rate variability indices.

Keywords: Coronary artery bypass grafts (CABG); Electrophysiology; Off-pump surgery

Introduction

The off-pump cardiac surgeries can be beneficial to the patent by causing less mortality, stroke and atrial fibrillation, compared to on-pump; [1,2] however, the mental strain imposed on the cardiac surgeon during off-pump operations in contrast to on-pump ones has not been previously investigated and recent studies have cast doubt on its effectiveness in graft patency [3]. Off-pump procedures can be more exhausting to a cardiac surgeon, especially while grafting the posterior coronaries (LCX, OM), when there is a risk of hemodynamic changes and loss of the patient.

One of the more favourable methods in evaluating mental stress is the heart variability, which is a balance between the sympathetic and parasympathetic nervous systems. The heart rate variability indices consist of heart rate, low frequency (LF), high frequency (HF), and low frequency/ high frequency ratio (LF/HF). The HF spectral component is the result of the parasympathetic system and the LF/HF is controlled by the sympathetic system, but there is controversy over the LF inasmuch as some regard sympathetic modulation and others consider the effect of both sympathetic and parasympathetic nervous systems as being responsible for its generation. [4,5] Amongst these indices, the LF/HF ratio has been proposed as a non-invasive quantitative measure of the autonomic nervous system activity [6] and is a favoured measurement of stress level.

Seeking to test the hypothesis that off-pump CABG leads to a more pronounced strain and mental stress for the operator compared to on-pump CABG, we utilized the popular method of the heart rate variability indices of the surgeon while performing these two types of surgical operations.

Materials and Methods

The heart rate indices of a cardiac surgeon were monitored throughout 17 on-pump and 16 off-pump CABGs. The surgical operations were performed between May 2009 and July 2009. The exclusion criteria were surgeries in which the surgeon had slept less than 7 hours during the previous night or when he had an unexpected stress during the previous 12 hours. The procedures with concomitant valve surgeries were also excluded. Informed written consent was obtained from all the patients, and the study protocol was approved by our institutional Ethics Committee on Human Study.

The surgical phases and the overall difference between the two types of CABGs were compared.

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The cardiac surgeon, MHM, was healthy, did not have a personal or family history of cardiac disease, and did not take any medications. Before the commencement of the study, the surgeon underwent a CT-angiography, which proved normal. He had 20 years of experience in the field of cardiovascular surgery and had performed approximately 6,500 off-pump and 3,500 on-pump operations during the previous 10 years.

The electrocardiogram was monitored by a recording device (RAC-3103, Nihon Kohden, Japan) throughout the procedures. The recorded digital data were transferred to a computer after each operation and analyzed with the Reynolds Medical Research Tools software. The heart rate variability was evaluated by the frequency domain of the tachogram. The length of the tachogram and the type of the analysis were based on the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology [5].The power spectral density was measured using the fast Fournier transformation. Amongst the spectral components, a high frequency (0.15 to 0.4 Hz) and a low frequency (0.04-0.15 Hz) were considered. The LF/HF was calculated since it presents a good measure of stress and sympathetovagal activity [5,7,8]. The absolute (millisecond square) and normalized units were expressed for power and frequency of LF and HF. For normalized units the calculation was done from the relative values of each power component to the total power minus very low frequency. The surgery was divided into 6 phases, illustrated in Table 1.

Statistical analysis

The data are expressed as mean and standard deviation (SD). The longitudinal changes in the phases of the surgical operations were compared between the two groups via repeated measurements.

All the statistical analyses were performed using the SPSS Ver11.0 program. A significance level of $P < 0.05$ was used for all the comparisons.

Results

The patients' mean age was 56.6 ± 6.6 years and their mean ejection fraction was 48.2 ± 6.2. The patients' previous medical condition included diabetes in 33.3% and chronic renal failure in 6.1%. As regards grafts, 11 patients required 3 grafts, 18 patients 4 grafts, 3 patients 5 grafts and 1 patient received only one graft.

Patient background difference in two groups are shown in Table 2 and the difference in heart rate variability indices during different phases between off-pump and on-pump opeartion are shown in Table 3.

In the off-pump operations, the LF increased gradually until the unclamping phase and it afterwards decreased to its base level (Figure 1).

In the on-pump procedures, the LF decreased gradually until the time of distal anastomosis, remained constant during distal anterior anastomosis, and then increased to its base level by the time of proximal anastomosis (Figure 1).

The HF in the off-pump surgeries showed a dramatic decline during posterior distal anastomosis and it increased gradually afterwards and reached its base level by the time of proximal anastomosis (Figure 2).

In the on-pump operations, a gradual decline was seen also for the HF until the time of posterior anastomosis and it subsequently returned gradually to its base level by the time of proximal anastomosis (Figure 2).

The LF/HF in the off-pump procedures showed a significant increase during posterior distal anastomosis and it thereafter declined gradually to its base level by the time of proximal anastomosis (Figure 3).

The LF/HF in the on-pump surgeries showed an increase at the time of cannulation and cardiopulmonary bypass and it decreased afterwards to its base level in by the time of posterior distal anastomosis and remained almost constant until the end of the operation (Figure 3).

The heart rate increased gradually in the off-pump procedures during posterior distal anastomosis; there was a significant surge in the surgeon's heart rate, which declined afterwards but it did not reach the base level (Figure 4).

phase I	incision
phase II	cannulation and CPB on
phase III	distal posterior anastomosis
phase IV	distal anterior anastomosis
phase V	unclamping
phase VI	proximal anastomosis

Table 1: Six phases during coronary artery bypass grafting.

On-Pump	Off-Pump	P-Value
56.9 ± 5.6	56.3 ± 7.8	0.770
15/2	8/8	0.026
46.2 ± 6.0	50.3 ± 5.9	0.055
11.8	56.3	0.007

Table 2: Patient characteristics.

Variables	Group	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	P-Value between groups	P-Value between phases
LF	On Pump	86.12±3.92	84.65±4.05	81.88±4.97	81.71±4.31	85.65±3.43	86.12±3.24	0.485	0.002
	Off Pump	83.31±4.36	83.00±4.24	86.19±4.94	84.81±4.04	88.12±3.50	84.00±4.13		
HF	On Pump	16.00±1.06	15.00±2.83	14.65±0.70	14.82±0.81	15.24±0.75	15.82±0.95	< 0.0001	< 0.0001
	Off Pump	15.06±1.12	14.81±0.75	12.13±1.03	12.50±1.03	13.44±0.89	15.38±0.72		
LF/HF	On Pump	5.40±0.36	6.11±2.74	5.60±0.42	5.53±0.42	5.64±0.38	5.46±0.35	< 0.0001	< 0.0001
	Off Pump	5.56±0.55	5.62±0.42	7.15±0.71	6.82±0.48	6.59±0.56	5.48±0.41		
Heart Rate	On Pump	60.1±2.8	62.1±3.3	66.1±4.8	62.5±2.5	68.9±5.6	60.5±3.1	< 0.0001	< 0.0001
	Off Pump	64.5±4.9	69.6±3.7	89.7±9.2	80.1±7.9	76.6±5.0	74.8±7.1		

Table 3: during different phases the difference in heart rate variability index between on-pump and off-pump are demonstrated.

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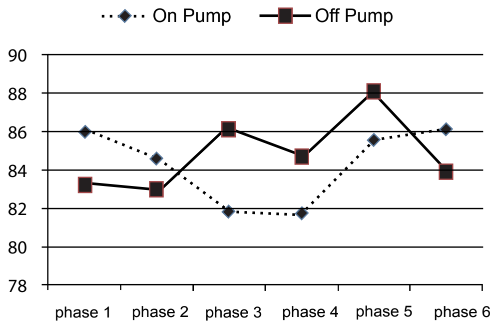
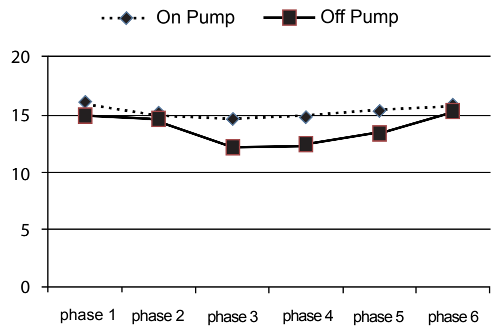


P-Value for difference between types of operation =0.48|

P-Value for difference between phases =0.002

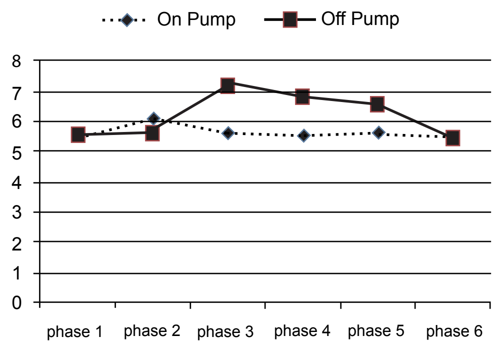
Figure 1: The Low Frequency level during different phases of off-pump and on-pump CABG.



P-Value for difference between types of operation <0.0001

P-Value for difference between phases <0.0001

Figure 2: The High Frequency Level during different phases of off-pump and on-pump CABG.



P-Value for difference between types of operation <0.0001

P-Value for difference between phases <0.0001

Figure 3: The Low Frequency /High Frequency level during different phases of off-pump and on-pump CABG.

In the on-pump operations, there was also a mild increase in the heart rate during posterior distal anastomosis; it subsequently decreased and then had a larger surge at the time of unclamping (Figure 4).

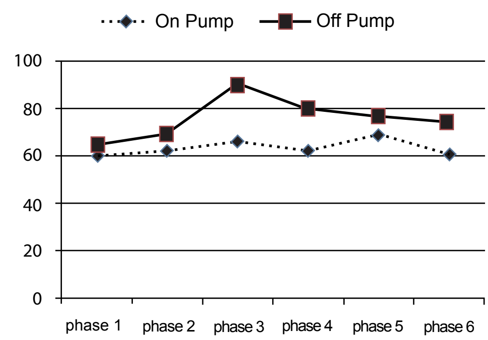
Two patients developed hemodynamic changes, during which the heart rate had the highest level.

Discussion

Our results indicate that the off-pump operations are more stressful to the surgeons this was shown as a result of increase in heart rate variability indices. Stress can cause a surge in overall sympathetic activity and, as a result, shift the indices of the heart rate variability towards the sympathetic system. [5,9,10] The mental strain of a surgical operation can increase the sympathetic activity in surgeons [11,21].

Heart rate has been previously used as a measure of stress level. Foster et al. showed a higher intra-operative heart rate for the surgeon compared to their clinic hours [11]. Another study compared the heart rate of anaesthesiologists and surgeons, showing a higher level of heart rate in the latter. [12] Mongin et al. [13] evaluated the heart rate of some general surgery residents during surgical operations and found that the residents had the highest heart rate during the draping of the surgical field, trocar placement, clip application, and extraction of gallbladder during laparoscopy. Other reports have linked an increased heart rate to an increased level of atherogenic lipids [14]. It is also worthy of note that intra-operative stress, especially if sustained, can be recognized as a risk factor for the development of ischemic heart disease. In our study, the heart rate of the surgeon had a statistically significant difference between the off-pump and on-pump operations, which can be an indicator of the higher stress level in the former modality. In our study, the heart rate difference was at its highest during posterior distal anastomosis, which is expected insofar as it is considered a critical time during surgery with the risk of causing hemodynamic changes for the patient.

The heart rate variability indices are important indicators of the physiologic function of the heart and can be a better indicator of stress level than the heart rate alone. [7,11,12,15,16] A decreased heart rate variability index has been an indicator of mortality in patients with myocardial infarction or congestive heart failure [17,18]. On the other hand, a decreased heart rate variability index is a risk factor for coronary artery disease [19]. Pagani et al. [20] showed that psychological stress could move the balance of the autonomic system activity towards the sympathetic dominance [20]. An increased sympathetic system can reduce the heart rate variability; [21] In surgeons the sustained heightened sympathetic system activation can be a predisposing factor for coronary artery disease.



P-Value for difference between types of operation <0.0001

P-Value for difference between phases <0.0001

Figure 4: Heart Rate during different phases of off-pump and on-pump CABG.

The Dermitas et al. [22] study showed a higher level of sympathetic activity for the surgeon and residents during the operation time compared to the normal office hours, with the main difference between the two beings in the LF/HF ratio: there was a 66 % increase in the ratio for the surgeon and 43% increase for the assistant. Moreover, as this ratio indicated sympathetic activity, they concluded that that there was an increased level of sympathetic activation for the surgeons, which reflected the higher level of mental strain.

Bohm et al. [7] studied the heart rate variability index of the surgeon during segmental sigmoid resection with and without laparoscopy and found a lower level of HF, a higher level of LF, and an increased LF/HF for the laparoscopic surgery. The heart rate difference between the two groups was not statistically significant and in our study in contrast the LF component was not statistically significant different between the two types of operation however the LF component was higher during most part of the off-pump operation.

Song et al. [23] used the LF/HF ratio to measure stress level of the cardiac surgeon and compared the stress level when the surgeon was performing the coronary operation himself and when he was supervising the residents. When the surgeon was performing the operation the stress was highest during the beginning of operation and decreased gradually, however when he was supervising the residents the ratio was high during cardiac arresting, performing coronary arteriotomy, and anastomosis of the grafts. In our study, we found a statistically significant difference between the off-pump and on-pump CABGs in terms of the LF/HF ratio. In contrast to the study by Song et al. [23], we did not find the beginning of the operation particularly stressful; rather the highest level of LF/HF was found during posterior distal anastomosis in the off-pump surgeries and during cannulation in the on-pump operations.

It should be noted that the intrinsic heart rate variability changes by such factors as age, gender, weight, exercise, innervations, smoking, and right atrial stretch, which affect the autonomic function. [7,24-26] To eliminate this bias, we had the hear rate variability monitored in one surgeon.

In general, the mortality rate of medical doctors does not seem to be different from that of the general population; however, surgeons have a higher rate of ischemic heart death, [27,28] which can be related to the mental strain that they experience in the operating room [7]. The mental stress of a cardiac surgeon in the operating room is considerable because any inadvertent incident can cost the patient's life. The use of beta-blockers has been suggested to lower the surgeon's heart rate during surgery, to lower the operator's stress, and to suppress the autonomic function and as a result reduce the risk of coronary artery disease [11,22]. Whether the use of beta-blockers for the selective, more demanding operations such as off-pump surgeries, would be beneficial requires further investigation.

Our results indicated that off-pump CABG was more exhausting for the surgeon compared to on-pump CABG, and this was shown by the statistically significant difference between the two surgical modalities and the higher level of the LF/HF ratio; the correlation of this ratio and mental strain has been previously demonstrated [8,20]. We also found that the LF/HF ratio during the off-pump procedures was at its highest during posterior distal anastomosis. Be that as it may, as was previously stated by Bohm et al. [7] there is no cut-off point for the risky mental strain. Needless to say, some types of surgical operations are more stressful, more time-consuming and could be too risky to perform multiple times through the day.

The main limitation of this study is that this is a case study and it's hard to generalize our finding on the other hand the patients background was significantly different regarding sex and diabetes, the effect of this difference on our finding is not clear on the other hand the criteria for off-pump operation is higher risk patients which may also cause more stress for the cardiac surgeon. Our results also differ from Song et al. [23] unlike our study they found the beginning of the operation particularly stressful, this may indicate that the most stressful phase may not be the same for every surgeon.

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