

# Effect of Different Left Ventricular Pacing Sites on Cardiac Output

M.D. Mohammad Hosein Nikoo <sup>1</sup>, M. D. Masoud Shafiee <sup>2</sup>, M. D. Zahra Mehdipour Namdar <sup>1</sup>, M.D. Mostafa Kazerooni <sup>3</sup>, M.D. Mohammad Vahid Jorat <sup>1</sup>, M.D. Amir Aslani <sup>1\*</sup>

<sup>1</sup>Cardiovascular Research Center, Shiraz University of Medical Science, Shiraz, Iran

<sup>2</sup>Cardiac Surgery Department, Kowsar Hospital, Shiraz, Iran

<sup>3</sup>Anesthesiology Department, Kowsar Hospital, Shiraz, Iran

Correspondence Author E-mail: [draslani@yahoo.com](mailto:draslani@yahoo.com)

## ABSTRACT

**Background:** Epicardial wire can be placed in any epicardial position during open heart surgery. The aim of this study was to evaluate the effect of different epicardial pacing sites on cardiac output in patients who underwent cardiac surgery.

**Method:** Patients who underwent coronary artery bypass grafting were selected for this study. Epicardial wire was implanted at 4 locations: 1-RV near apex (usual site); 2-LV near apex; 3-LV upper lateral; 4-LV upper septal anterior. External single chamber generator was used and pacing rate was 10 beat/ minute greater than patient heart rate. Cardiac output (CO) was measured by NICO system which uses Fick's method to calculate cardiac output from respiratory O<sub>2</sub> and CO<sub>2</sub>.

**Result:** In all patients, CO during patients' sinus rhythm was more than RV apical pacing ( $P < 0.001$ ), LV apical pacing ( $P=0.016$ ) and LV upper septum pacing ( $P=0.002$ ). Regarding left versus right side of pacing, LV lateral wall make significantly more output than RV apex ( $P=0.005$ ). When left sides are compared, LV lateral wall create more output than LV apex ( $P < 0.001$ ). In comparison, LV apex produces more output than LV upper septum ( $P < 0.001$ ). Also output from LV lateral wall pacing exceeds LV upper septum ( $P < 0.001$ ). So the best LV site for pacing seems to be LV lateral wall.

**Conclusion:** Pacing from left ventricular lateral wall pumps blood most efficiently than other sites of LV and RV wall. This finding suggests LV lateral wall as a best site for post cardiac surgery pacing.

**Key words:** Cardiac output; Pacing; Left ventricle; Right ventricle; Cardiac surgery

## Correspondence:

Amir Aslani  
Cardiovascular Research Center, Shiraz  
University of Medical Science  
Shiraz  
Iran

E-mail Address: [draslani@yahoo.com](mailto:draslani@yahoo.com)

Submitted: 25-03-2020

Revision: 20-04-2020

Accepted Date: 10-05-2020

DOI: 10.31838/jcdr.2020.11.02.03

## INTRODUCTION

Temporary epicardial wire implantation is a routine procedure after open heart surgery<sup>(1)</sup>. Usually, the epicardial wire is placed in the right ventricle (RV). RV pacing induces asynchronous electrical activation of the left ventricle (LV) which may have deleterious effects on cardiac function<sup>(2,3,4,5,6,7)</sup>. However, epicardial wire can be placed in any epicardial position during open heart surgery. The aim of this study was to evaluate the effect of different epicardial pacing sites on cardiac output in patients who underwent cardiac surgery.

## MATERIAL AND METHODS

### Study Population

Thirty-six, Consecutive adult patients who underwent coronary artery bypass grafting from 2010-2011 in Kowsar Hospital; were selected for this study. Patients gave the written informed consent to participate in the study which was approved by the local ethics committee. All patients were in sinus rhythm. Each patient paced temporarily from 4 sites mentioned in surgical intervention and cardiac output was measured.

### Exclusion Criteria

Patients with the following criteria were excluded from the study:

1-Previous pacemaker implantation; 2-Atrial fibrillation; 3-Complete left bundle branch block (QRS > 120 msec); 4-

Hemodynamic instability after pump; 5-Ejection fraction < 30%

### Surgical Intervention

Epicardial wire was implanted at 4 locations:

1-RV near apex (usual site); 2-LV near apex; 3-LV upper lateral; 4-LV upper septal anterior

Medtronic external single chamber generator was used (Medtronic, Minneapolis, Minnesota, USA). Pacing was performed 10 beat/minute greater than patient heart rate for 1 minute. Ventricular capture during pacing was confirmed by QRS morphology.

### Cardiac Output Measurement

NICO (Non-Invasive Cardiac Output- Novametric, Wallingford, CT, USA) is a device using Fick's method to calculate cardiac output (CO) from respiratory O<sub>2</sub> and CO<sub>2</sub><sup>(8)</sup>.

### Statistical Analysis

All values are presented as means ± SD. Differences between groups were performed using Friedman & Wilcoxon tests. SPSS 11.0 software was used for statistical analysis. For all analyses, P value < 0.05 was considered as statistically significant.

## RESULTS

### Patients Characteristics

A total of 36 patients (26 male, Age: 56±19 years) were included in the study. Ejection fraction of the study population was 50.4% ± 10.2%. Indication for coronary artery bypass grafting was 3 vessels disease (with or without left main disease) in 72% of patients, 2 vessels disease in 24% and single vessels disease in 4% of the study population. Each patient paced from 4 mentioned sites and cardiac output was measured.

### Results of Epicardial Pacing

Table1 shows results of CO from different epicardial pacing sites. In all patients, CO during patients' sinus rhythm was more than RV apical pacing ( $P<0.001$ ), LV apical pacing ( $P=0.016$ ) and LV upper septum pacing ( $P=0.002$ ). Table2 shows comparison between cardiac outputs from different epicardial pacing sites. Regarding left versus right side of pacing, LV lateral wall make significantly more output than RVapex ( $P=0.005$ ). When left sides are compared, LV lateral wall create more output than LV apex ( $P<0.001$ ). In comparison, LV apex produces more output than LV upper septum ( $P< 0.001$ ). Also output from LV lateral wall pacing exceeds LV upper septum ( $P< 0.001$ ). So the best LV site for pacing seems to be LV lateral wall (Figure-1).

## DISCUSSION

During pacing from ventricular site, electrical wave should pass from cell-to-cell with slow conduction velocity, which is more time consuming, and less efficient for producing stroke volume<sup>(7)</sup>. In our study, in keeping with these facts, we found that left ventricular pacing produces better CO than RV pacing. Also, we found that LV lateral wall pacing produces the best CO in comparison with other LV sites. This might be explained by less ventricular dyssynchrony during pacing from LV lateral wall (compared to other LV sites)<sup>(7)</sup>.

Normal heart uses His-Purkinje system to deliver electrical stimuli to whole endocardial sites spontaneously and this causes harmonic spiral movement of ventricles with excellent output. Ventricular pacing from any site loses such advantage of atrio-ventricular synchrony and harmonic contraction with less efficient working<sup>(5, 6, 7)</sup>. This fact reconfirmed in our study as maximum cardiac output was during normal sinus rhythm.

Effect of epicardial pacing on cardiac output after open heart surgery was studied in a few articles by echocardiography<sup>(7)</sup>. Echocardiographic measurement of CO is complex and matter of controversy<sup>(10,3)</sup>. This makes us to estimate this effect by another method and NICO seems simple and reasonably accurate<sup>(8,9)</sup>. NICO method has good correlation with standard thermo- dilution method but is non-invasive, automated and useful<sup>(10)</sup>. However, our finding was similar to the echocardiographic researches<sup>(7)</sup>.

## STUDY LIMITATION

The present research has some limitations: 1) Dual chamber pacing from atrial and ventricular sites (A-V synchronous pacing) produces better CO than single chamber (ventricular) pacing. In the present study, single chamber

pacing was performed because of time limitation during cardiac bypass surgery; 2) It was more informative if we checked CO from all ranges of LV function, but in our study we excluded the patients with EF<30% due to critical time limitation in such patients.

## CONCLUSIONS

Pacing from left ventricular lateral wall pumps blood most efficiently than other sites of LV and RV wall. This finding suggests LV lateral wall as a best site for post cardiac surgery pacing.

## COMPETING INTEREST

The authors declare that they have no competing interest.

## ACKNOWLEDGEMENT

We thanks Mrs. Hajipour and Mrs. Falamarzi for English editing.

## CONFLICT OF INTEREST

None

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**Table 1:** Results of Cardiac Output from Different Epicardial Pacing Sites

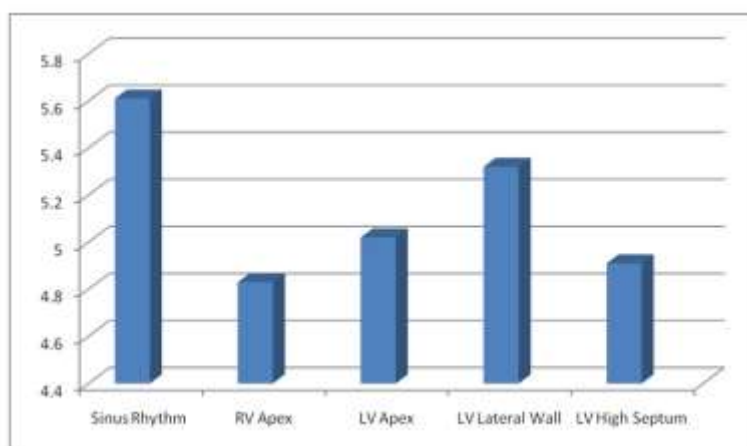
Site of Epicardial Pacing	Cardiac Output (liter per minute) (mean ± SD)
Patient's Sinus Rhythm	5.61 ± 0.52
RV Apex	4.83 ± 0.69
LV Apex	5.02 ± 0.56
LV Lateral Wall	5.32 ± 0.61
LV High Septum	4.91 ± 0.48

RV=Right Ventricle, LV=Left Ventricle

**Table 2:** Comparison between Cardiac Outputs from Different Epicardial Pacing Sites

Site of Pacing	Cardiac Output (L/min)	Pvalue
Sinus Rhythm vs. RV Apex	5.61 ± 0.52 vs. 4.83 ± 0.69	<0.001
Sinus Rhythm vs. LV Apex	5.61 ± 0.52 vs. 5.02 ± 0.56	0.016
Sinus Rhythm vs. LV Lateral	5.61 ± 0.52 vs. 5.32 ± 0.61	<0.001
Sinus Rhythm vs. LV Septum	5.61 ± 0.52 vs. 4.91 ± 0.48	0.002
RV Apex vs. LV Apex	4.83 ± 0.69 vs. 5.02 ± 0.56	<0.001
RV Apex vs. LV Lateral	4.83 ± 0.69 vs. 5.32 ± 0.61	0.005
RV Apex vs. LV Septum	4.83 ± 0.69 vs. 4.91 ± 0.48	< 0.001
LV Lateral vs. LV Apex	5.32 ± 0.61 vs. 5.02 ± 0.56	< 0.001
LV Septum vs. LV Apex	4.91 ± 0.48 vs. 5.02 ± 0.56	0.010
LV Lateral vs. LV Septum	5.32 ± 0.61 vs. 4.91 ± 0.48	< 0.001

RV=Right Ventricle, LV=Left Ventricle



**Figure 1:** Shows results of cardiac output from different epicardial pacing sites. In all patients, cardiac output during patients' sinus rhythm was more than RV apical pacing, LV apical pacing and LV upper septum pacing. The best site for pacing seems to be LV lateral wall. (RV=Right Ventricle, LV=Left Ventricle)