Original Article

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Transesophageal echocardiographic measurement of coronary sinus blood flow to estimate the adequacy of revascularization in patients undergoing coronary artery bypass graft: a prospective observational study

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Abstract

Background: Oxygen supply to the myocardium is determined mainly by the amount of the coronary blood flow. Transesophageal echocardiography is being widely used intraoperatively during cardiac surgery. We studied to compare coronary sinus blood flow using Transesophageal echocardiography before and after coronary artery bypass grafting to determine the adequacy of surgical revascularization in a single cardiac centre in Nepal.

Methods: Twenty patients scheduled for elective coronary artery bypass grafting were included in this study. After induction of anesthesia according to institutional protocol, a transesophageal echocardiography probe was inserted into patients' esophagus, and velocity time integral of coronary sinus, coronary sinus diameter, and coronary sinus blood flow per beat at pre-revascularization and post-revascularization periods were recorded.

Results: The velocity time integral in the post-revascularization period was significantly higher as compared with the pre-revascularization period (P<0.000). Coronary Sinus diameter in the post-revascularization period was significantly larger as compared with the pre-revascularization period (0.59 vs.0.56 cm) (P<0.000). There was a significant increase in coronary sinus blood flow per beat in the post-revascularization period (4.45±0.66ml) as compared with the pre-revascularization period (4.29±0.65ml) (P<0.000).

Conclusion: Transesophageal echocardiography can be used to measure the adequacy of revascularization in CABG patient by measuring the change in real time coronary sinus blood flow before and after revascularization.

Keywords: Coronary artery bypass graft, Transesophageal echocardiography, coronary sinus

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BACKGROUND

Oxygen supply to the myocardium is determined mainly by the amount of the coronary blood flow. In presence of coronary lesions and myocardial ischemia the coronary blood flow decreases so, measurement of the amount of coronary blood flow helps in evaluating the presence of any coronary diseases. Measurement of coronary blood flow can be assessed by coronary sinus blood flow (CSBF). In patients with coronary artery disease, there is reduced CSBF. Any intervention done to increase coronary perfusion may also increase CSBF.

Measurement of CSBF is done by various invasive techniques that require cardiac catheterization using intracoronary Doppler flow wire, thermodilution catheter, or digital coronary angiography. It can also be measured using radioisotope dyes such as argon technique or xenon scintigraphy[1].

Transesophageal echocardiography (TEE) is being widely used intraoperatively during cardiac surgery. Because the echocardiographic probe is located in the esophagus in proximity to the left atrioventricular junction, the TEE can demonstrate

the coronary sinus (CS) with high resolution. Besides this, it can evaluate CSBF in real time with good reproducibility and allows the monitoring of flow before and after the revascularization procedures.

Limited studies has been done using TEE to assess CSBF and see the improvement in coronary artery perfusion after surgical revascularization. The aim of this study is to compare CSBF using TEE before and after coronary artery bypass grafting (CABG) to determine the adequacy of surgical revascularization in a single cardiac centre in Nepal.

Method

This was a prospective observational study performed at Shahid Gangalal National Heart Center of Nepal. After obtaining Institutional review board approval a written informed consent was obtained from all the patients age above 18 years who were scheduled for elective isolated CABG surgery and not having any of the exclusion criteria (patients' refusal, patient under mechanical ventilator prior to surgery, patients' with ejection fraction <45%, accompanying valvular or other cardiac surgery and emergency Surgery) were enrolled in the study.

Demographic details of the patients were recorded. After the patient was brought to the operation theatre, standard monitoring such as electrocardiography and pulse oximetry were applied. Invasive blood pressure monitoring line and central venous catheter through right internal jugular vein were inserted under standard aseptic precautions. The anesthetic induction was done with midazolam, fentanyl, and propofol as per standard hospital protocol. In all patients, neuromuscular blockade was provided by vecuronium. After anesthetic induction, an appropriatesized (7 for female and 7.5 for male) cuffed high volume low pressure endotracheal tube (ETT-portex, Smiths Medical ASD, INC, USA) was used to secure the airway. Mechanical ventilation was started with volumecontrolled mode with the tidal volume of 8 ml/kg of predicted body weight, respiratory rate of 12 per minute, inspiratory/expiratory ratio 1: 2 and inspiratory oxygen fraction(FiO2) 0.6 with an airoxygen mixture with isoflurane. After that, TEE probe (Philips EpiQ7, USA) was inserted after adequate lubrication and a brief jaw thrust maneuver. Experienced cardiac anesthesiologist inserted the probe and managed all cases. Bite guard was used after TEE probe placement.

By using B-mode echocardiography the image of CS was obtained in modified four chamber view. The pulse doppler sample volume was placed in the CS 1 cm before its inflow in the right atrium. The transducer position was optimized to obtain an angle of less than 40° between the Doppler beam and direction of CSBF. After induction of anesthesia and five minutes after complete revascularization, velocity time integral (VTI) of CS was recorded and diameter of CS was measured by using M-mode. Assuming that the cross-section of CS is elliptical and that the major diameter is double the length of the minor diameter, the cross-section area of CS was calculated as 0.39× diameter of CS[4]. CSBF per beat was then calculated as CS VTI × cross-sectional area of CS. Hemodynamic parameters including heart rate, mean atrial pressure and central venous pressure before and after revascularization were recorded.

Collected data were analysed by means of statistical software SPSS-22. Statistical analysis for demographic variables was done by chi-square test and student's paired t test was applied to compare the mean difference in CS diameter, VTI and CSBF before and after revascularization. P-value of < 0.05 was considered to be statistically significant.

Results

The demographic data of the patient are as shown in Table 1. The hemodynamic parameters in terms of heart rate and mean arterial pressure though seemed to be changed statistically significantly before and after revascularization, but the range of change was within the acceptable range of 20% of baseline as shown in Table 2. The difference in central venous pressure wasn't statistically significant.

The velocity time integral in the post-revascularization period was significantly higher as compared with the pre-revascularization period (P<0.001). Coronary Sinus diameter in the post-revascularization period was significantly larger as compared with the pre-revascularization period (0.59 vs.0.56 cm) (P<0.001). There was a significant increase in coronary sinus blood flow per beat in the post-revascularization period (4.45±0.66ml) as compared with the pre-revascularization period (4.29±0.65ml) (P<0.001) as shown in Table 3.

Table 1: Demographic data of the patients

Variables	
Sex (M:F)	11:9
Age(Years)	62.5(51-76)
Weight (kg)	61(52-88)
Height (cm)	155(145-172)
Number of grafts	3.5(3-5)

Tables 2: Comparison of Hemodynamic parameters

	Before revascularization (mean+/- SD)	After revascularization (mean+/- SD)	P value
HR (in mins)	66.60±7.88	73.50±7.48	0.001
MAP (mmHg)	81.70±12.99	74.50±5.97	0.001
CVP (mmHg)	13.40±3.08	13.70±2.56	0.428

Tables 3: Comparison of TEE findings

	Before revascularization (mean+/- SD)	After revascularization (mean+/- SD)	P value
CS VTI (cm)	14.33±2.18	14.82±2.19	0.001
CS diameter (cm)	0.56±0.12	0.59±0.12	0.001
CSBF per beat(ml)	4.29±0.65	4.45±0.66	0.001

DISCUSSION

In CABG various arterial or venous grafts are used in the obstructed vessels in order to increase the coronary artery blood flow. The patency of these graft is the major factor for the success of this surgery. So, proper evaluation of the patency of the graft intra-operatively is very important. Intraoperative assessment tools for

measurement of graft patency include transit time flowmetry and intraoperative fluorescence coronary angiography. However, these measurement modalities aren't available in our center. So, surgeons often use the crude evaluation technique like finger palpation of the graft to assess the patency of graft.

CS drains the venous blood from its tributaries like great cardiac vein, middle cardiac vein, and small cardiac vein. These veins drain the venous blood from the myocardial that is supplied by coronary arteries. Any intervention that aims at restoring the flow of the stenosed vessel increases coronary artery flow that should consequently increase the CSBF. Measurement of CSBF can be used as an indirect tool for the assessment of adequacy of coronary artery perfusion after surgical revascularization[1].

Though measurement of CSBF is done by various invasive techniques that require cardiac catheterization using intracoronary Doppler flow wire, thermodilution catheter, or digital coronary angiography and radioisotope dyes such as argon technique or xenon scintigraphy1-4, but these techniques cannot be used intra-operatively in the operating room. As the use of intraoperative TEE is a routine practice in cardiac surgery, we used TEE to evaluate the change in CSBF after revascularization.

Our study findings showed that the velocity time integral in the post-revascularization period was significantly higher as compared with the pre-revascularization period ($p<0.001$). Coronary Sinus diameter in the post-revascularization period was significantly larger as compared with the pre-revascularization period (0.59 vs.0.56 cm) ($p<0.001$). There was also a significant increase in coronary sinus blood flow per beat in the post-revascularization period (4.45±0.66ml) as compared with the pre-revascularization period (4.29±0.65ml) ($p<0.001$).

In a study done by Meenakshi K et al. to find the change in CSBF after percutaneous coronary angioplasty, they performed transthoracic echocardiography and measured the CS diameter and CSBF. The CSBF per beat increased from 3.06±1.12 to 4.2±1.80 ($p<0.038$) in their study and their result was comparable to our study.

In similar study done by Prajapati M et al. they also found significant improvement in CS diameter (0.68 vs.0.79 cm), CS VTI(16.53 vs 19.66) and CSBF per beat (3.04 vs 4.90) after revascularization in off pump CABG patients. Their findings were also in consistent to our study findings.

Ng DW et al[1]. did transthoracic echocardiography to see the CSBF before and after CABG. They also found significant change in CS VTI from 10.6±1.93 to 13.4±2.3 ($p=0.01$) and significant change in CSBF after revascularization. However, they didn't notice any significant change in CS diameter in their study. The difference noted in CS diameter in our study could be due to the use of retrograde cannula in our study population which could have also contributed in change of the diameter of coronary sinus post revascularization.

In a study done by Hajaghaei M et al. they found CS diameter increased from 8.6 ±1.06 to 9.4±1.21 ($p<0.01$) 1 month after CABG and their findings were also similar to our study findings.

All of our study population didn't develop any complications in the post-operative period and none required intra-aortic balloon pump placement. They were hemodynamically stable throughout their post-operative period and were discharged home with satisfactory outcome.

This study has some limitations, which mainly are related to low number of study patients. In addition, the study was done in on-pump CABG patients with retrograde cannulation in the coronary sinus which could have also contributed in change of the diameter of coronary sinus post revascularization. We also recommend to undergo further studies in off-pump CABG patients as well in the future.

Conclusion

Transesophageal echocardiography can be used to measure the adequacy of revascularization in CABG patient by measuring the change in real time coronary sinus blood flow pre and post revascularization. So, we recommend to use TEE measurements of CSBF to look for the changes in blood flow after the surgery.

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Conflict of interest statement:

We declare no perceived or potential conflicts of interest within past 36 months related to this study.

Authors' Contributions: SS Parajuli and RB Adhikari designed the study, took part in acquisition, analysis and interpretation of data, created the initial draft of the manuscript and made critical revisions.

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