



PHRENIC NERVE ICE SLUSH INJURY; COMPARISON BETWEEN DIABETIC AND NON-DIABETIC PATIENTS UNDERGOING ON-PUMP CORONARY ARTERY REVASCULARIZATION WHEN LIMA NOT TAKEN AS CONDUIT

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ABSTRACT:

BACKGROUND: This study was performed to find out the incidence of phrenic nerve injury in diabetic patients, undergoing CABG with use of ice slush, when LIMA was not used for grafting.

METHODOLOGY: This prospective randomized case control study was conducted at Department of Cardiothoracic Surgery, Punjab Institute of Cardiology, Lahore from 1st January 2009 to 31st March 2016. 450 patients, both men and women aged 45-70 years, undergoing elective Coronary Artery Bypass Grafting (CABG) were included. Patients were divided into two groups. Group A had diabetes mellitus and Group B did not. SPSS (Statistical Package for Social Sciences) for Windows version 21 was used for the analysis of data. A p-value of ≤ 0.05 was taken as significant.

RESULTS: A total of 450 were enrolled in the study where the mean age of patients was 54.5 ± 5.5 10 years. In Group A, 108 males were diabetic. Twenty five patients developed abnormal diaphragmatic movements ($p = .000$), 15 patients had atelectasis on chest x-ray and 29 patients had elevated left hemidiaphragm, 15 patients had pleural effusion on left side and 46 patients had developed nosocomial pneumonia ($p = 0.000$ each). All such variables were found at insignificant level for group B patients.

CONCLUSION: Phrenic nerve injury is a significant complication of ice slush usage, especially in patients with diabetes who undergo coronary artery bypass grafting.

KEYWORDS: Phrenic nerve ice slush injury, diabetes mellitus, coronary artery revascularization

INTRODUCTION:

Myocardial protection is one of the most integral component of effective cardiac surgery outcome.¹ In addition to hypothermia and hyperkalemic cardioplegia, the ice slush over the left side of heart is most often used by the majority of cardiac surgeons, for further cardio-protection.²⁻⁴ However, some have also proposed against the benefits of topical cooling with ice slush as this does not provide additional cardioprotective effects.⁵⁻⁷ Once used the Ice slush

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is not without hazard²⁻⁶ and is thought to injure phrenic nerves especially the left phrenic, which runs over the pulmonary side of pericardial tissue, enroute to diaphragm.

The phrenic nerve injury is either partial or complete, temporary or permanent.³⁻⁶ Diabetes been suggested as independent factor for phrenic nerve injury.² Once it occurs, the presentation is myriad. However this injury can be avoided by not using ice slush at all, or even if used for a shorter and minimal time.^{6,7}

This study was performed to find out the incidence of phrenic nerve injury in diabetic patients, undergoing coronary artery revascularization surgery with use of ice slush as cardioprotector, where left internal mammary artery (LIMA) was not harvested, to avoid the mechanical injury to the phrenic nerve near ostium of LIMA.

METHODOLOGY:

This prospective randomized case control study was performed at Department of Cardiothoracic Surgery, Punjab Institute of Cardiology, Lahore, Pakistan, from 1st January 2009 to 31st March 2016. Both men and women aged 45-70 years,

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undergoing elective Coronary Artery Bypass Grafting (CABG) were included in the study. However, patients for emergency and Redo CABG, where LIMA was harvested as a conduit, OPCAB and combined valve surgery, those patients with associated additional cardiac pathologies (aortic aneurysm and congenital heart disease, detected preoperatively on echocardiography and angiography), patients with chronic obstructive pulmonary disease, chronic cough, obesity (BMI \geq 30) and neurological disorders were excluded.

All cases were operated at the same Institute. Patients were preoperatively assessed as per routine. In all cardiac procedures, central catheterization via the right internal jugular vein was preferred because left phrenic nerve injury is more common. All operations were performed with sternotomy under cardiopulmonary bypass with single 2-stage venous cannulation, and after cooling to 30-34°C, with cardiac diastolic arrest by antegrade Hyperkalemic blood cardioplegia. Ice slush either was applied all the time during CABG directly over the left anterolateral surface of heart. Once the procedure was over, cross clamp was made off the ascending aorta, top ends of conduits placed, CPB was disconnected along with its connections. Patient was normothermized (37°C). Hemostasis maintained and drains along with pericardial pacing wires placed. After the procedure Stainless-steel no.5 wire were used in all cases for sternum closure. Rest of the wound was closed in layer as standard policy.

Among the patients in whom LIMA was not harvested and only the venous grafts were placed, we divided them into two groups. Group A had patients with diabetes mellitus and Group B had non diabetic patients. The first 225 cases were collected belonging to each category of groups. Both had Ice slush placed in pericardial well during the CABG. A pre-designed proforma was used, that recorded demographic data of patients, cardiopulmonary bypass time, cross clamp time, total operation time, time on mechanical ventilation, delayed extubation, re-intubation, total ICU stay, pleural effusion, nosocomial pneumonia, reciprocal diaphragmatic / abdominal movement, total hospital stay, Chest x-ray findings (elevation of diaphragm, pleural effusion, disordered movement of diaphragm in expiration and inspiration) before operation during hospital stay and after 6 weeks of operation, need for chest intubation and mortality.

SPSS (Statistical Package for Social Sciences) for Windows version 21 was used for the analysis

of data. All qualitative variables & quantitative variables were presented in the form of mean \pm standard deviation and tables, pie & bar charts. Frequency of PNI was compared in both groups by using Pearson chi-square test, Fischer Exact Test. A p-value of \leq 0.05 was taken as significant.

RESULTS:

A total of 450 were enrolled in the study where the mean age of patients was 54.5 \pm 5.510 years, with male and female number of patients was approximately similar (n=217 vs n=233). The preoperative ejection fraction was between 51-60% in 385 (85.6%) patients. At the time of operation both pleura remained intact in 110 patients (24.4%) whereas right pleura was found opened inadvertently in 194 patients (43.1%) and the left pleura in 48 patients (10.7%) while in 98 patients

Table 1: Comparison of patient characteristics among Group A and B

Variables	Diabetics (Group A)	Non-Diabetics (Group B)	P-value	
Age	56.35 \pm 5.805	52.65 \pm 4.505	0.0467	
Male / Female	108/117 (48% and 52%)	109/116 (48.4% and 51.6%)	0.925	
Chest Intubation	57(25.3%)	0	0.001	
Ischemic-Patho	stable angina	46(20.4%)	56(24.9%)	0.527
	unstable angina	106(47.1%)	99(44%)	
	ACS	73(32.4%)	70(31.1%)	
LVESD	40-45 mm	202(89.8%)	205(91.1%)	0.331
	46-50 mm	19(8.4%)	12(5.3%)	
	51-55 mm	4(1.8%)	7(3.1%)	
	56-60 mm	0	1(0.4%)	
LVEDD	50-55 mm	63(28.0%)	57(25.3%)	0.443
	56-60 mm	147(65.3%)	146(64.9%)	
	61-65 mm	15(6.7%)	22(9.8%)	
EF	41-50 %	30(13.3%)	22(9.8%)	0.166
	51-60 %	186(82.7%)	199(88.4%)	
	> 61%	9(4.0%)	4(1.8%)	
Pleura	Intact	42(18.8%)	68(30.2%)	0.008
	Right pleura opened	111(49.3%)	83(36.9%)	
	Left pleura opened	20(8.9%)	28(12.4%)	
	both pleura opened	52(23.1%)	46(20.4%)	
LA	<45 mm	39(17.3%)	36(16%)	0.149
	46-55 mm	112(49.8%)	115(51.1%)	
	56-65 mm	71(31.6%)	62(27.6%)	
	66-75 mm	3(1.3%)	9(4.0%)	
	> 76 mm	0	3(1.3%)	

(21.8%) both pleura were found opened iatrogenically. Time on ventilation postoperatively was found to be < 1 day in 92.7% patients. Total ICU stay was upto 2 days in 96.2% patients, whereas the total hospital stay was upto 7 days in 96.9 patients. A total of 15 patients developed pleural effusions, 59 had nosocomial pneumonia, and 17 deaths were noted.

In Group A, 108 males were diabetic. Twenty five patients developed abnormal diaphragmatic



Table 2: Comparison of In-Hospital Variables among Group A and B

Variables	Diabetics (Group A)	Non-Diabetics (Group B)	P-value
Abnormal Chest X ray	44(19.55%)	15(6.67%)	0.001
Abnormal Diaphragmatic movement	25 (11.1%)	2 (0.9%)	0.001
Nosocomial Pneumonia	46(20.4%)	13(5.8%)	0.001
Pleural effusion	15(6.7%)	0	0.001
CPB time (>80 min)	78(34.67%)	56(24.89%)	0.122
Cross Clamp time (>40 min)	60(26.67%)	54(24%)	0.209
Hypothermia (>40 min)	60(26.67%)	54(24%)	0.928
ICU Stay (>2 days)	7(0.311%)	10(4.44%)	0.597
Hospital Stay (>7 days)	6(2.67%)	5(2.22%)	0.337
Reintubation	10(4.4%)	11(4.9%)	0.823
Mortality	4(1.8%)	13(5.8%)	0.026

movements ($p=.001$), 15 patients had atelectasis on chest x-ray and 29 patients had elevated left hemidiaphragm, 15 patients had pleural effusion on left side and 46 patients had developed nosocomial pneumonia ($p=0.001$ each). All such variables were found at insignificant analysis for group B patients. However, only 4 mortalities were reported in Group A, whereas it was 13 for Group B patients during the study period. (Table 1)

DISCUSSION:

Respiratory distress secondary to diaphragmatic paralysis following cardiac surgery is a troubled complication. This is related in several cases to regional cooling-related phrenic nerve injury (PNI).^{2,8} During early days of cardiac surgery diaphragm paralysis has been reported radiologically with an incidence varying from 30% to 75%.⁹ Diabetes and the use of iced slush are independent predictors of phrenic dysfunction.² When compared to unilateral paralysis, patients with bilateral diaphragmatic paralysis are higher risk group, requiring different management methods, and having poorer prognosis.⁸

In our study we compared that incidence of phrenic nerve injury in diabetic patients, based on clinical examination findings and the findings on chest x-rays over a period of 6 months in patients who underwent coronary artery surgical revascularization. As ice slush was used in all patients the only variable of difference in both groups to compare remained Diabetes mellitus.

Nikas et al⁷ studied 505 consecutive patients who underwent CABG. They found that patients who received ice slush for cardioprotection had greater incidence of diaphragmatic paralysis with increased pulmonary complication. Similarly Allen et al¹⁰ retrospectively analysed 150 patients who underwent CABG. They found higher incidence of atelectasis, higher left diaphragm and longer hos-

pitalization in patients with ice slush usage. Diehl J et al⁶ reported diaphragmatic dysfunction in 2.1% when iced slush was used ($P < 0.005$). Thirteen of their patients developed complications e.g. cardio-respiratory arrest after early tracheal extubation in 5 patients, nosocomial pneumonia in 11, prolonged mechanical ventilation in all and a fatal outcome in 3. Brodaty et al¹¹ studied the long-term course of cold-induced phrenic nerve injury. It was found that such patients had significantly increased incidence of infectious and respiratory complications including atelectasis, bronchial obstruction, pleural effusion, pneumonia and prolonged assisted ventilation and intensive care stay. Moreover, Brodaty et al¹¹ mentioned that there are several studies which demonstrated that the use of topical hypothermia is associated with increased diaphragmatic paralysis and pulmonary complications.

When we look at the results of our study we find no specific difference from the studies mentioned above. In our study ice slush injury to phrenic nerve was significantly apparent in diabetic patients, with statistically significant development of abnormal diaphragmatic movements, atelectasis on chest x-ray, elevated left hemidiaphragm, pleural effusion on left side and nosocomial pneumonia ($p=0.001$ each).

Maccheriniet al³ found when ice slush was used there appeared transitory diaphragmatic paralysis, as well as pleural effusions and need for thoracentesis. However, Efthimiou J et al¹ found that their patients developed unilateral diaphragm paralysis which was still present in 19 patients (34%) at 1 month and in 5 patients (9%) at 1 year postoperatively. Similarly Brodaty et al¹¹ showed often incomplete regression of the phrenic nerve paralysis 1 year later. Moreover, long-term follow-up data from Brodaty et al¹¹ showed often incomplete regression of the phrenic nerve paralysis. In our study however no clinical or x-ray findings were present 6 months postoperatively. Alassar et al showed there was no evidence of any additional cardioprotective benefit.¹²

Surprisingly Nikas,⁷ Allen,¹⁰ Braathen⁵ and Brodaty¹¹ et al found that there is no improvement in postoperative hemodynamics, reduction in inotropic requirements, enzyme release or risk of myocardial infarction, when surgeons used local application of ice slush for cardioprotection. We therefore believe that in patients who are diabetic and undergoing coronary revascularization procedure, its better to avoid ice slush and if surgeon still likes to put it inside pericardial well, keep it there



for a minimum time in order to avoid morbidity and mortality in this group of patients, who are already at risk of neuropathies.

CONCLUSION:

Phrenic nerve injury is a significant complication of ice slush usage, especially in patients with diabetes who undergo coronary artery bypass grafting.

Author's Contribution

SA: Conducted the study and wrote the article. AA: Helped in conducting the study and gave frequent advice. WR: Helped in collecting and re-analyzing the data. SS: proof reading MI: Statistician. MA: SMT: Frequently advice

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