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The value of intra-operative epiaortic scanning in patients submitted for coronary artery bypass grafting

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Abstract---The aim of the work to assess the value of epiaortic ultrasound prevention of stroke and other postoperative complications, and whether its use leads to changes of planned intra-operative surgical management in patients undergoing CABG surgery compared its performance to TEE. 100 patients who underwent primary isolated CABG from may 2016 into may 2017 as it represent 40% of total primary isolated CABG was done in this time. Patients were prospectively randomized into Two groups. These study was performed in KOBRY EL KOBBA Military Hospital. Patients were divided into Epiaortic group "Group A" and TEE & palpation group "Group B". The primary endpoint of this study was an incidence of early post-operative stroke. The secondary endpoint of this study was an incidence of early post-operative MI, AF, renal failure, deep wound infection.

Keywords---stroke, epiaortic scan, outcome, TEE, CABG.

Introduction

Stroke is the dreaded complication of cardiac surgery. Atherosclerosis of the ascending aorta and the aortic arch is one of the most significant risk factors for peri-operative stroke. Patients undergoing coronary artery bypass grafting (CABG) are known to carry increased risk of stroke, and other complications ⁽¹⁾. Stroke and neurocognitive dysfunction are common after cardiac surgery with rates of approximately 3-6% and 30-50%,. patients with one or more risk factors as (Advanced age, female sex, previous stroke, transient ischemic attack, carotid bruits, hypertension, diabetes mellitus, congestive heart failure, and extensive aortic calcification have all been associated with increased risk of operative strokes) ⁽⁵⁾ this affects consent and operative planning⁽¹⁾.

Most of strokes are embolic in nature and are discovered early after surgery (≤ 24 hours postoperative), one of the important causes of stroke is ascending aortic atherosclerosis. So to avoid this single reason (asc aortic atherosclerosis) comes the value of measures offered to counter it: palpation, numerous diagnostic techniques have been proposed to identify patients who are at increased risk of aortic atherosclerotic changes. Modalities such as non-contrast computed tomography, transesophageal echocardiography (TEE), and intra-operative epiaortic scan (EAS) have all been shown to detect the atheromatous aorta with differing abilities ⁽⁶⁾.

Unlike other operative procedures, the manipulation of the ascending aorta is standard practice in all open heart procedures. Dislodgement and embolization from the ascending and arch atheromas have been associated with direct manipulation of the aorta, cannulation, and cross-clamping ⁽³⁾. Stroke and neurological injury are among the most devastating and disabling complications associated with cardiac surgery. Epiaortic ultrasound and transesophageal echocardiography screening are more accurate and more accessible to the operative team than any other available modality to diagnose atherosclerosis of the aorta ⁽²⁾.

To reduce the risk of operative-related strokes in this patient population, surgeons have started to use methods to reduce interference with plaque-laden aortas. The use of off pump coronary bypass, echo-guided cannula/clamp placement, and no touch aortic procedures, among others, have been the most widely used. EA is a part of the operative plan in all patients, and the conduct of the operation is altered based on its findings. As a result, we have investigated our recent experience to help further delineate the benefit of intra-operative EA in patients undergoing isolated primary CABG ⁽⁷⁾.

Patients and Methods

That study was conducted after obtaining the approval of the local ethical committee and a written formal consent from all patients for the purpose of the study, The study was done at the kobry el koba military hospital. In the period between October 2016 and October 2017. That study was a prospective comparative non randomized controlled trial encompassing 100 patients undergone primary isolated CABG (50 patients using TEE and palpation, and 50

patients with using Epiaortic scan). Data collection were done Using checklist, data compilation form as research tools.

In that study we compared early post-operative neurological outcome after on-pump, off pump after using of EAS in group A and TEE in group B. Emerging evidence suggested that EAS may be capable of detecting atheromatous plaques more than TEE , surgical modification stratige, and possibly reducing the incidence of neurological and systemic insults during cardiac surgery. The collected data were statistically applied & entered to SPSS software programs to get the final results. Results were presented in tables. The final conclusion is based on the results of the study data.

Study population:

The patients divided into two groups:

- **Group A:**
50 patient, Epiaortic group (aortic manipulation of the proximal ascending aorta was guided by epiaortic scanning).
("GE i 13l Probe compatible with Vivid 7 machine")
- **Group B:**
50 patient, TEE & palpation group (guided by trans-esophageal echocardiography and manual palpation by the operating surgeon).
(examination was performed obtaining all standard views using a multiplane 4–7 MHz probe connected to a Sonos 5500 TM echocardiography machine (Philips Medical Systems, Andover, MA)).

Those patients were selected according to the following inclusion and exclusion criteria:

Inclusion criteria:

- Adult patients > 40 years old.
- Candidate for CABG.

Exclusion criteria:

- MID-CAB surgery.
- Aortic arch surgeries.
- CABG with any associated procedures.
- Redo CABG.
- Emergency CABG.
- pre-existing atrial fibrillation.
- TEE was contraindicated, or when TEE revealed an intra-cardiac source of potential emboli.

Statistical Analysis

Statistical package for the Social Sciences (SPSS) version 26 (IBM Corp., Armonk, NY, USA) was used to summarize data into: mean, standard deviation, median, minimum and maximum in quantitative data and using frequency (count) and relative frequency (percentage). Non-parametric Kruskal-Wallis and Mann-Whitney tests were used to compare between quantitative variables 6 . Chi square (c2) test was performed to compare categorical data. Exact test was used instead when the expected frequency is less than 5(7) . *p*-values less than 0.05 were considered as statistically significant.

Results

Statistical analysis of 100 patients who underwent isolated CABG, The patients were classified into two groups:

In Group –"A" , age ranged from 46-73 years with a mean of 60 ± 10.1 , while in Group –"B" , age ranged from 48-71 years with a mean of 57.6 ± 13.5 , and there was no statistical significance (P value >0.05).

In Group –"A", there was 36 males (72%) and 14 females (28%), while in Group –"B" there was 40 males (80%) and 10 females (20%) with no statistical significance (P value >0.05).

Group –"A" , 38 underwent on-pump while 12 underwent off-pump under EAS, Group –"B", 44 underwent on-pump while 6 underwent off-pump under TEE and palpation.

Pre-operative assessment

Table (1): Demographic data and clinical characteristics of the patients

	Group A	Group B	P value
Number	50	50	
Age			
Range	46-73	48-71	
Mean	60.1	57.6	0.1
SD	16.1	13.5	
Gender %	72% males 28% females	80% males 20% females	0.29
BMI			
Mean	25.2	24.9	0.70
SD	2.4	2.7	
History of Smoking	22	23	0.50
Hypertension	39	36	0.50
DM	35	33	0.46
PVD	2	2	0.78
NYHA			
1, 2, 3, 4	31, 9, 8, 2	32, 10, 6, 2	0.59
Unstable angina	0	0	NS
Chronic renal disease	0	0	NS
Left main disease	12	13	0.5

Table (2): Pre-operative Atheroma grading system (Number & %)

	Group A	Group B	P value
I, Normal	22(44%)	8(16%)	<0.01
II, Mild	16(32%)	36(72%)	<0.01
III, Moderate	5(10%)	4(8%)	0.77
IV, Severe	3(6%)	2(4%)	0.82
V, Severe	4(8%)		

Table (3): Pre-operative echocardiographic data

	Group A	Group B	P value
Ejection fraction %	63 ± 4.1	61.3 ± 4.3	0.65
Left ventricle end diastolic dimension	5.9 ± 1.0	5.1 ± 0.27	0.91
Left ventricle end systolic dimension	3.8 ± 0.69	3.26 ± 0.49	0.74

Intra-operative course:

The intra-operative surgical data e.g. cross-clamp time and total bypass time were comparable in these study groups.

In **Group "A"** 38 cases (76%) was aortic cannulated, while 12 cases (24%) converted to off-pump surgery.

In **Group "B"** 44 patients (88 %) was aortic cannulated, while 6 patients (12 %) were converted to off-pump CABG.

Intra-operative surgical management was changed in 12 patients in the Epi-aortic group and 6 patients in the palpation group from on-pump CABG into off-pump CABG, $p > 0.01$.

Table (4): Cross clamp & total bypass time, Total operation time in both groups

	Group A	Group B	P value
Cross clamp (min.)	87.8 ± 8.7	60.1 ± 6.5	>0.01
Total bypass time	118.1 ± 9.6	87 ± 5.77	>0.01
Total operation time (mean ± SD) (hours)	4.2 ± 0.46	3.83 ± 0.46	>0.01

Although EAS detected more lesions than TEE resulting in more change of surgical strategy in this group the incidence of stroke was the same. In both groups, the result between patients which had similar rates of early post-operative MI, AF, renal failure, deep wound infection.

Post-operative course:

No significant difference with respect to peri-operative morbidity and mortality between the two groups.

Table (5): Post-operative complications of both groups

	Group A	Group B	P value
Mortality	0(0.0%)	0(0.0%)	NS
Stroke	0(0.0%)	0 (0%)	NS
Myocardial infarction	0(0.0%)	0 (0%)	NS
Renal failure	0(0.0%)	0 (0%)	NS
Atrial fibrillation	3 (6%)	4 (8%)	0.05
Deep wound infection	1 (2%)	2 (4%)	0.66
No complications	44 (88%)	41 (82%)	0.82

All patients in both groups were admitted one day before surgery. The total hospital stay was comparable in the two groups; the range of hospital stay in group “A” was 5-8 days with a mean of 6.6 ± 1.9 days, while in group “B” the range was 4-12 days with a mean of 9.4 ± 3.8 days. This shows that the total hospital stay in group A is less than group B, and this difference has a highly statistical significance as shown in table (6).

Table (6): Total hospital stay of both groups

	Group A	Group B	P value
Total hospital stay	5-8	4-12	>0.01
Range	6.6	9.4	
Mean	0.9	0.8	
SD			

All the patients completed the study without any mortality.

Discussion

Cerebrovascular accident (CVA) after coronary artery bypass grafting (CABG) remains one of the most dangerous complications. Incidence of stroke after CABG ranges from 1 to 6%. Its etiology is multifactorial including cerebral embolization from iatrogenic mobilization of atherosclerotic plaques, air / fat embolism, peripheral vascular disease (PVD), hemodynamic fluctuations, cerebral hyperthermia, and systemic inflammatory reaction ⁽¹⁸⁾.

Methods of identifying the atheromatous aorta include non-contrast computed tomographic scanning of the chest and trans-esophageal echocardiographic identification of atheromatous deposits in the aortic wall. Intra-operative EAS has been shown to be superior to TEE or palpation alone in identifying aortic atheromatous lesions, especially in the mid to distal ascending aorta ^{(12),(8)}, thus making it the modality of choice in identifying ascending aortic atheroma ⁽⁸⁾.

The introduction of EAS into clinical practice was associated with a reduction in the prevalence of stroke from 1.2% to 0.7% in prospective review of 100 patients undergoing CABG surgery. Hammon and colleagues, further showed that a surgical strategy designed to minimize aortic manipulation guided by EAS

significantly reduced the incidence of cognitive deficits in CABG patients compared with traditional techniques. Others have reported that alterations of surgical techniques based on assessments for atherosclerosis of the ascending aorta reduces the prevalence of TCD-detected cerebral emboli and clinically reported stroke ⁽¹³⁾. In our study the method of assessment of atheroma used was TEE and EAS.

Preoperative data

As regard detect aortic atheroma, Suvarna and colleagues demonstrated that EAS is the gold standard to detect atheroma, as results was the sensitivity of both TEE and palpation were low. TEE & palpation detect 32% of patients, in contrast, EAS detect atheroma in 68% of patients⁽⁸⁾. In our study, TEE & palpation detect only 4% of severe atheroma, 8% of moderate atheroma, in contrast, EAS detect atheroma 14% of severe grade atheroma, 10% of moderate atheroma ⁽²⁶⁾.

As regard degree of atheroma, Hangler and colleagues demonstrated that intraoperative screening of CABG patients by EAS can reveal useful information about the operative risk and with an aortic no-touch concept , perioperative stroke rates in high risk patients may be lower than predicted ^{(9),(7)}. Hangler and colleagues results was the degree of ascending atherosclerosis was normal to mild in 42.9% patients, moderate in 47.5% patients, and severe in 9.6% patients. The operative technique was modified in 31.1% of patients with moderate aortic sclerosis and in 91.2% of patients with severe aortic sclerosis. Perioperative mortality was 0% for mild disease, 3% for moderate disease, and 8.8% for severe disease. Corresponding stroke rates reaches 2%, 2.4%, 2.9%⁽⁹⁾. In our study, the degree of ascending atherosclerosis was normal to mild in 76% patients, moderate in 10% patients, and severe in 14% patients. The operative technique was modified in 24% of moderate and severe aortic sclerosis.

Operative data

As regard intraoperative surgical managment, Djaiani and colleagues demonstrated that the use of EAS led to modifications in intraoperative surgical management (adjustment of ascending Aorta cannulation site, conversion to off-pump surgery) in almost one-third of patients undergoing CABG surgery. The use of EAS did not lead to a reduced number of TCD-detected cerebral emboli before or during CPB, Djaiani and colleagues results was intraoperative surgical management was changed in 29% patients in EAS group and in 12% patients in the control group, the TCD detected cerebral emboli count did not differ between the EAS and control group ⁽⁴⁾.

In our study, the intraoperative surgical management was changed in 24% patients in EAS group and in 12% patients in the TEE group, in both groups no difference between the EAS and TEE group as no strokes detected. As regard aortic clamping, Yamaguchi and colleagues demonstrated that application of aortic cross clamping or CPB was not risk factor of cerebral emboli when the ascending aorta was evaluated using the EAS, as results was the use of intraoperative EAS to evaluate ascending aorta in CABG patients. When scanning documented more than 3 mm of atheromatous thickness or plaque in ascending

aorta, we never manipulate it. Therefore 21.6% underwent off-pump CABG using composite grafts 9.4% or in situ grafts 12.2% with no aortic manipulation. The ascending aorta was confirmed to be free from significant atheromatous plaque by the EAS in 78.4%. on-pump CABG was performed using aortic cannulation and total aortic clamping in 47.2%⁽²⁰⁾.

in our study, 24% underwent off-pump CABG using composite grafts 14% or in situ grafts 10% with no aortic manipulation. The ascending aorta was confirmed to be free from significant atheromatous plaque by the EAS in 44%. On-pump CABG was performed using aortic cannulation and total aortic clamping in 76%. As regard clinical benefit of EAS, H.-C.JOO and colleagues demonstrated that EAS has significant clinical benefit in reducing the incidence of early stroke in cases of partial aortic clamping in on-pump CABG. H.-C.JOO and colleagues results in the **EAS group**, 23.7% patients underwent on-pump with partial aortic clamping & 76.3% underwent on-pump without partial aortic clamping. In the **non-EAS group**, 31.1% patients underwent on-pump with partial aortic clamping and 68.9% underwent on-pump without partial aortic clamping. The incidence of early stroke was not different statistically between the EAS and non-EAS groups (non-EAS 1.7% vs EAS 0.8%) however, in the subgroups of patients with partial aorta clamping, the incidence of early stroke was significantly lower in the EAS group (2.8% vs 0.7%) ⁽¹⁹⁾.

Hangler and colleagues demonstrated that patients with severe atherosclerosis whose therapy was modified on the basis of EAS had a lower rate of stroke (2.9%) than a historical control group (4.4%). These studies suggested a clinical benefit of EAS ⁽⁹⁾. Suvarna and colleagues compared EAS with both TEE and surgical palpation in 100 patients undergoing cardiac surgery and found that EAS was superior to both TEE and surgical palpation for the detection of atherosclerosis in the mid and distal segment of the ascending aorta ⁽⁸⁾.

In our study, Group (A) 38 underwent on-pump while 12 underwent off-pump applying EAS, whereas Group (B) 44 underwent on-pump while 6 underwent off-pump applying TEE and palpation. Group (A) incidence of early stroke was (0%) the same with Group (B) as all patients gained maximum protection with overcrossing in suspicious cases in Group (B) by EAS. In EAS group the use of EAS method for demonstrating & grading of atheroma in the aorta , modification of proximal sites and alteration of intra-operative surgical management in group "A" , and due to its accuracy in identification of atheroma some cases in TEE group were over crossed by EAS for further protection ⁽²²⁾.

Avoidance of aortic atheroma by using EAS to guide surgical interventions would likely primarily reduce TCD embolic signals due to solid emboli containing atheromatous debris. Further, positioning of the aortic cannula away from an atherosclerotic portion of the aorta might reduce solid emboli that result from the effects of CPB inflow or the "sand blasting" effect ⁽¹⁵⁾.

Another approach is to find with EAS a suitable location for cannulation, construct the distal anastomoses with cold fibrillatory arrest while cooling the patient, and then construct a proximal anastomosis without clamping the aorta using a brief period of circulatory arrest. The other vein grafts may be connected

to the first as the patient is re-warmed. With the increasing use off-pump techniques to re-vascularize the myocardium it is possible to avoid all manipulation of the ascending aorta (**'no touch' technique**) by constructing bypass grafts with arterial conduits such as the internal thoracic (mammory) arteries without cardiopulmonary bypass ⁽²¹⁾. Vein grafts and free arterial grafts may be connected to the in situ arterial conduits. Some devices were also developed to reduce embolic risk. One such device allowed rapid vein graft anastomosis with the aorta without the need for cross-clamping. However, the higher risk of adverse outcome, including early graft closure precluded its wide spread adoption ⁽¹⁰⁾.

Postoperative data

As regard postoperative complication, in a study performed by Yamaguchi et al, 2009 the postoperative stroke ranges from 1.4% to 3.8% associated with 19% of in-hospital mortality, in study performed with van der linden and colleagues ⁽³⁾, could not show a reduction in the prevalence of postoperative strokes with minor modifications in surgical technique in a series of 921 consecutive patients undergoing cardiac surgery. the prevalence of strokes in their series was 1.8% in patients without atherosclerosis disease of the ascending aorta and 8.7% in patients with the disease despite minor surgical modifications. in the group of patients who underwent the beating heart and aortic no-touch concept, the stroke rate was near 0% , in a study performed by patel and colleagues ⁽²⁵⁾, have also described a near 0% stroke rate using beating heart total revascularization without aortic manipulation was (2 ± 5 day) in group A while in group b was (2 ± 4 day) ⁽²⁰⁾,

in a study performed by Davila-Roman et al ⁽²⁷⁾, also reported that there was >1.5-fold increase in the incidence of both neurologic events and mortality as the severity of atherosclerosis increased from normal-mild to moderate, and a greater than threefold increase in the incidence of both as the severity of atherosclerosis increased from normal-mild to severe.

In our study, There was no difference between both two groups in results as regard between both primary & secondary endpoints, as all patients gains the maximum protection in group "A" & group "B", ALL detected atheroma in aorta conversion from on-pump into off-pump, while group "B" some cases overcrossing by EAS for more protection. Constant improvement in the surgical and CPB management techniques as well as have resulted in a reduction of the number of embolic events in most of the patients undergoing cardiac surgery. Cerebral embolic count could be considerably reduced by thorough surgical and perfusionist management, including placement of an air tight purse-string suture around the venous cannula, distal aortic arch cannulation, and prevention of air entrapment into the CPB circuit by meticulous perfusionist interventions ⁽¹⁶⁾.

As regards of complications of EAS, as discussed by Rosenberger et al, ⁽²⁸⁾ complications of EAS are rare. Because the probe is placed in a sterile, fluid filled bag, any perforation of the bag may lead to contamination of the surgical field. in our study, We have not found this to be a problem and think it of little risk. There is some argument about the length of time required to perform an examination,

but we have found that our exams rarely take more than a few minutes. Some argue that the interpretation of the ultrasound is time consuming and difficult to learn but, the American Society of Echocardiography and Society of Cardiovascular Anesthesiologists both recommend this training as a core component of their advanced certification ⁽¹⁷⁾.

Conclusion

Epiaortic scanning (EAS) is superior to manual palpation of the ascending aorta and to trans-esophageal echocardiography (TEE) as it's fast, non invasive, and sensitive technique that provides information of the ascending aortic wall in its entire length and circumference for the detection of atherosclerosis of the ascending aorta, particularly of non-calcified plaques ⁽²⁶⁾. These results show that the use of EAS led to modifications in intra-operative surgical management in almost half of patients undergoing CABG surgery. The use of EAS did not lead to a reduced number of cerebral emboli before or during CPB ⁽²³⁾.

We reported that even patients with mild-to-moderate atheroma of the ascending aorta undergoing coronary artery bypass graft (CABG) surgery with cardiopulmonary bypass (CPB) with the use of EAS does not developed any ischaemic brain injury that was associated during CPB ^{(11) (29)}. EAS may reduce the frequency of neurological injury after surgery due to cerebral embolism by allowing for the identification and, thus, avoidance of atheroma at the sites of ascending aortic manipulations (e.g., cannulation for CPB, aortic cross-clamping, and proximal CABG anastomosis) ⁽²⁴⁾.

The primary objective was to examine whether EAS use leads to changes in the planned surgical management compared with manual palpation and TEE. The secondary objective was to determine whether the use of EAS leads to a reduction in cerebral embolic load in patients undergoing CABG surgery.

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