Original Article

Systematic Review and Pooled Meta-analysis of the Current Status of Coronary Revascularization Surgery in Bangladesh

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Abstract

Background: There is no consensus on the role of beating heart coronary artery bypass graft surgery (BECAB) in adult Bangladeshi patients requiring coronary revascularization surgery. We aimed to conduct a systematic review on all literature related to BECAB and/or conventional (CCAB) to determine the comparability of the patient outcomes of BECAB with that of a controlled cohort.

Method: We carried out a systematic review according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines. A meta-analysis was conducted to compare clinical outcomes between the BECAB and CCAB cohorts. Pooled analyses were also performed to determine the incidence rates of any adverse outcomes related to CABG.

Results: We observed significantly lower rates of operation time (MD: -52.30, CI: -67.73 to -36.86, p<0.0001), ventilation time (MD: -8.64, CI: -9.47 to -7.82, p<0.0001) and ICU stay (MD: -17.47, CI: -33.57 to -1.38, p=0.03) associated with BECAB. From our pooled analyses of the BECAB cohort, we observed that the average blood loss was 500.303 [352.099, 648.507], while the average rates of perioperative MI (0.020 [0.002, 0.049]), stroke/TIA (0.015 [0.000, 0.042]), AKI (0.006 [0.002, 0.012]), respiratory complications (0.020 [0.000, 0.058]) and low output syndrome (0.123 [0.106, 0.141]) were all lower than the averages observed in the CCAB cohort.

Conclusion: In an adult Bangladeshi CABG population, the clinical outcomes of patients that underwent BECAB were non-inferior to, if not better than, patients who underwent CCAB.

Keywords: *BECAB: Beating heart coronary artery bypass surgery; CCAB: Conventional coronary artery bypass surgery; Coronary Artery Bypass, Bangladesh*

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Introduction:

In the era of changing prospects of clinical practice in coronary revascularization surgery, beating heart coronary artery bypass surgery (BECAB) is gaining popularity worldwide as well as in Bangladesh. On

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average, more than 10,000 patients undergo coronary artery bypass graft (CABG) surgery each year.[1] As coronary artery disease continues to remain one of the most common forms of heart disease and is the single most significant cause of death in the adult Bangladeshi population,[2] the volume of CABG surgeries has only been increasing over the last decade.

As CABG surgery continues to evolve, developments in the field of CABG research has seen more focus on the arterial conduit with the introduction of newer long-acting cardioplegia and modifications to the surgical technique i.e. the minimally invasive approach.[3] Nevertheless, conventional CABG (CCAB) remains the more popular surgical procedure as a result of institutional practice and surgeon's preference.[4] Additionally, the overall patient outcomes of CABG have improved recently, but revascularisation of the heart still poses a greater risk of perioperative and postoperative death and morbidity.[3,4]

Changes in the practice of CABG in Bangladesh are up-to-date with the current research climate. In particular, recent reports have demonstrated that off-pump CABG is now widespread and has produced good clinical outcomes even in patients with left main coronary artery disease.[5] However, there is a paucity of studies reporting outcomes in larger patient cohorts that have been published within the last decade, with even fewer reports on BECAB being published in indexed medical journals.

Hence, there is a need for further research to be done in this area. A comparison of the named technique was therefore warranted. The objective of the present analysis was to quantify the clinical outcomes of coronary revascularization surgery in a standard adult Bangladeshi CABG cohort to reflect the incidence of early postoperative major adverse events (AEs) including myocardial infarction (MI), stroke, acute kidney injury (AKI), need for blood transfusion, atrial fibrillation (AF) and death. To achieve this objective, we systematically reviewed all relevant published literature in order to determine the average rates of each AE as well as discuss the comparability of off-pump CABG with conventional CABG in terms of patient outcomes.

Methods:

Search Strategy: A systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) standard.[6] We conducted electronic searches on Medline (via PubMed), Embase, Cochrane database records from the date of inception to 20 March 2020. On the PubMed database, a repetitive and exhaustive combination of the following 'Medical Subject Headings' (MeSH) search terms were used: "Aortocoronary Bypass", "Bypass Surgery", "Coronary Artery Bypass", "Coronary Artery Bypass Grafting", "Coronary Artery Bypass Surgery", "Coronary Artery Bypass, Off-Pump", "Beating Heart Coronary Artery Bypass", "Beating Heart Off-Pump Coronary Artery Bypass" and "Bangladesh". An alternative search on The Ubiquity Partner Network (UPN) via Bangladesh Journal Online (BanglaJOL)[7] was also performed using following search terms: "Aortocoronary Bypass, Bangladesh", "Bypass Surgery, Bangladesh", "Coronary Artery Bypass, Bangladesh" and other Mesh terms were repeated as mentioned above.

Inclusion criteria and exclusion criteria: Any prospective observational, interventional studies, retrospective cohort studies, case-control study, cross-sectional study and randomised controlled trials that reported clinical outcomes of both BECAB and/or CCAB surgery for coronary revascularization were included. Animal studies, experimental studies, survey results, small case series, case reports and studies that were not written in the English language were excluded.

Study selection: Three reviewers (F.S, A.L, G.G) screened and assessed the studies independently for inclusion. The scientific papers were first screened by their titles and abstracts, where the criteria used was purposely broad to include all relevant studies. The full text review was performed on articles if the reviewer was unable to confirm the relevance of the study for inclusion.

Three authors (F.S, A.L, M.K) independently abstracted the details of the study population, including preoperative baseline characteristics. In addition, data on all relevant clinical outcomes was obtained from each study for the generation of forest plots.

Quality of evidence and risk of bias assessment: As illustrated in chapter 11 of the Cochrane handbook of reviews to validate the quality of evidence found in our systematic review,[8] GRADEpro was used to evaluate the quality of evidence in the included studies (Table 1). As recommended in chapter 25 (section 25.3) of the online Cochrane Handbook version 5.1,[9] the software ROBINS-I tool[10] (Risk of Bias in Non-randomized Studies-of Interventions) was utilised to assess the risk of bias for non-randomized studies as seen in Table 2.

Table-I

Risk of bias of the included study for coronary revascularization surgery in Bangladesh

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Beating	Arrested	Relative (95% CI)	Absolute (95% CI)		
A. Assessed with: Trop I[11], BMI, AF, DM & Euroscore[11,14,16,28,34]												
5	NCC NCT	serious [a]	serious [b]	not serious	not serious	none	120/120 (100.0%)	180/240 (75.0%)	not estimable		⊕⊕◯◯ LOW	CRITICAL
B. Assessed with: Low EF, Radial Artery[12,32]												
2	RCT	serious [b]	serious [b]	not serious	not serious	publication bias strongly suspected [b]	30/200 (15.0%)	30/60 (50.0%)	not estimable		⊕◯◯◯ VERY LOW	CRITICAL
C. Assessed with: BIMA, Coronary Endarterectomy[17,33]												
2	RCS RSS	serious [a]	serious [c]	not serious	not serious	strong association	134/2781 (4.8%)	0/0	not estimable		⊕⊕⊕◯ MODERATE	CRITICAL
D. Assessed with: NCD HS-CRP[29]												
2	CSS	serious [a]	serious [b]	not serious	not serious	none	30/30 (100.0%)	100/100 (100.0%)	not estimable		⊕⊕◯◯ LOW	CRITICAL
E. Assessed with: MPV, Skeletonized IMA, BT, CEA, Aspirin Use, AF, RD, Low EF, DM, Euroscore, Tranexamic Acid use, Syntax Score and LM disease[15,18-27,30,31,35]												
14	POS PIS PCS	serious [a]	serious [a]	not serious	not serious	strong association	2204/3304 (66.7%)	362/362 (100.0%)	not estimable		⊕⊕⊕◯ MODERATE	CRITICAL

a. The study is an observational study with high risk of bias in confounding factors, b. Unspecified grouping of the study participants, c. Bias in selection of participants due to retrospective nature.

NCC: Nonrandomized controlled clinical study, **NCT**: Non-randomized Clinical Trail, **RCT**: Randomized Controlled Trail, **RSS**: Retrospective Study, **RCS**: Retrospective cross-sectional study, **CSS**: Cross sectional Study, **POS**: Prospective Observational Study, **PCS**: Prospective Cohort Study, **PIS**: Prospective Interventional Study. **CI:** Confidence Interval, **BMI:** Body Mass Index **AF:** Atrial Fibrillation, **DM:** Diabetes Mellitus, **EF:** Ejection Fraction, **BIMA:** Bilateral Internal Mammary Artery, **MPV:** Mean Platelet Volume, **CEA:** Carotid Endarterectomy, **HS-CRP:** High Sensitive C-Reactive Protein, **IMA:** Internal Mammary Artery, **BT:** Blood Transfusion, **RD:** Renal Dysfunction, **NCD**: Neurocognitive Dysfunction

Table-II
Summary of Included Studies

Sl	Author	Year	Study Design	Patients	BECAB	CCAB	Place of Study	Interest variable
BECAB and CCAB								
1	Badruzzaman et. al[11]	2010	Nonrandomized controlled clinical study	120	60	60	National Institute of Cardiovascular Diseases	Troponin I
2	Roy et. al[12]	2013	Randomized Controlled Trail	60	30	30	National Institute of Cardiovascular Diseases	Low Ejection Fraction
3	Ahmed et. al[13]	2018	Cross sectional Study	60	30	30	National Institute of Cardiovascular Diseases	Neurocognitive Dysfunction
4	Karim et. al[14]	2018	Non-randomized Clinical Trail	60	30	30	National Institute of Cardiovascular Diseases	Atrial Fibrillation
5	Alauddin et. al[15]	2019	Prospective Observational Study	100	50	50	Bangabandhu Sheikh Mujib Medical University	Renal Dysfunction
6	Kabir et. al[16]	2019	Nonrandomized controlled clinical study	60	30	30	National Institute of Cardiovascular Diseases	Euroscore
BECAB								
7	Saydur el al[17]	2016	Retrospective cross sectional study	134	134	0	United Hospital, Dhaka	Bilateral IMA
8	Sazzad et. al[18]	2016	Prospective Interventional Study	60	60	0	National heart Foundation Hospital & Research Institute	Skeletonized IMA
9	M Begum et. al[19]	2017	Prospective Observational Study	40	40	0	NICVD and BSMMU	Blood Transfusion
10	Ranjan et. al[20]	2017	Prospective Cohort Study	15	15	0	BSMMU and Al-Helal Specialized Hospital	Carotid Endarterectomy
11	R Karim et. al[21]	2018	Prospective Observational Study	48	48	0	National Institute of Cardiovascular Diseases	Use of Aspirin
12	Alam et. al[22]	2018	Prospective Interventional Study	100	100	0	National Institute of Cardiovascular Diseases	Atrial Fibrillation
13	Salekin et. al[23]	2018	Prospective Cohort Study	60	60	0	Bangabandhu Sheikh Mujib Medical University	Low Ejection Fraction
14	Ranjan et. al[24]	2019	Prospective Cohort Study	1403	1403	0	Bangabandhu Sheikh Mujib Medical University	Euroscore
15	Biswas et. al[25]	2020	Prospective Observational Study	428	428	0	National heart Foundation Hospital & Research Institute	Left main disease
CCAB								
16	Hasan et. al[26]	2016	Prospective Observational Study	81	0	81	National Institute of Cardiovascular Diseases	Mean Platelet Volume
17	Sazzad et. al[27]	2018	Prospective Observational Study	101	0	101	Ibrahim Cardiac Hospital & Research Institute.	Renal Dysfunction
18	J Alam et. al[28]	2018	Non-randomized Clinical Trail	60	0	60	National Institute of Cardiovascular Diseases	Body Mass Index
19	Rahman et. al[29]	2019	Cross sectional Study	70	0	70	National Institute of Cardiovascular Diseases	High Sensitive CRP
20	Ahsan et. al[30]	2019	Prospective Observational Study	60	0	60	National Institute of Cardiovascular Diseases	Diabetes Mellitus
21	Shahidullah et. al[31]	2019	Prospective Interventional Study	70	0	70	National Institute of Cardiovascular Diseases	Tranexamic Acid
Unspecified Group								
22	Alam et. al[32]	2017	Randomized Controlled Trail	200*	-	-	NICVD and Al-Helal Specialized Hospital	Radial Artery
23	Ranjan et. al[33]	2018	Retrospective Study	2647*	-	-	Bangabandhu Sheikh Mujib Medical University	Coronary Endarterectomy
24	Islam et. al[34]	2019	Non-randomized Clinical Trail	60*	-	-	National Institute of Cardiovascular Diseases	Diabetes Mellitus
25	Ranjan et. al[35]	2019	Prospective Observational Study	1100*	-	-	Bangabandhu Sheikh Mujib Medical University	Syntax Score
			Total (Group/Total)	**3190/7197**	**2518**	**672**		

** Unspecified grouping as per study requirement.* ***IMA:*** *Internal Mammary Artery,* ***NICVD:*** *National Institute of Cardiovascular Diseases,* ***BSMMU:*** *Bangabandhu Sheikh Mujib Medical University*

The risk of bias for each individual study[11-35] was mostly serious to critical. We believe that the retrospective and non-randomised nature of the included studies is responsible for these results. Since most of the studies used in the meta-analysis were observational studies, it has contributed to significant confounding and selection bias. The scientific journals reported that the surgeon's decision to proceed with BECAB or CCAB was heavily influenced by institutional practice and the expertise of the individual surgeon, which would somewhat explain the bias present in the studies. Moreover, a number of the included studies had missing data for the BECAB and/or CCAB groups, further contributing to the overall bias.

Data abstraction and outcomes of interest

Three authors (F.S, A.L, M.K) independently abstracted details of the study population. Data extracted included: Title, first author, year of publication, study type, number of patients. The primary outcome measures were operative outcome: operation time, number of grafts and in-hospital mortality. The secondary outcome measures were postoperative atrial fibrillation, ventilation time, length of ICU stay and duration of hospital stay.

Statistical analyses

All forest plots were generated using RevMan 5.3[36]. All meta-analyses were carried out using random-effects models to account for statistical variability across all studies that provided data of the clinical outcomes of coronary revascularization surgery. Pooled analyses of our results were carried out using the OpenMetaAnalyst Software[37]. We reported all the pooled results with 95% confidence intervals (95% CIs).

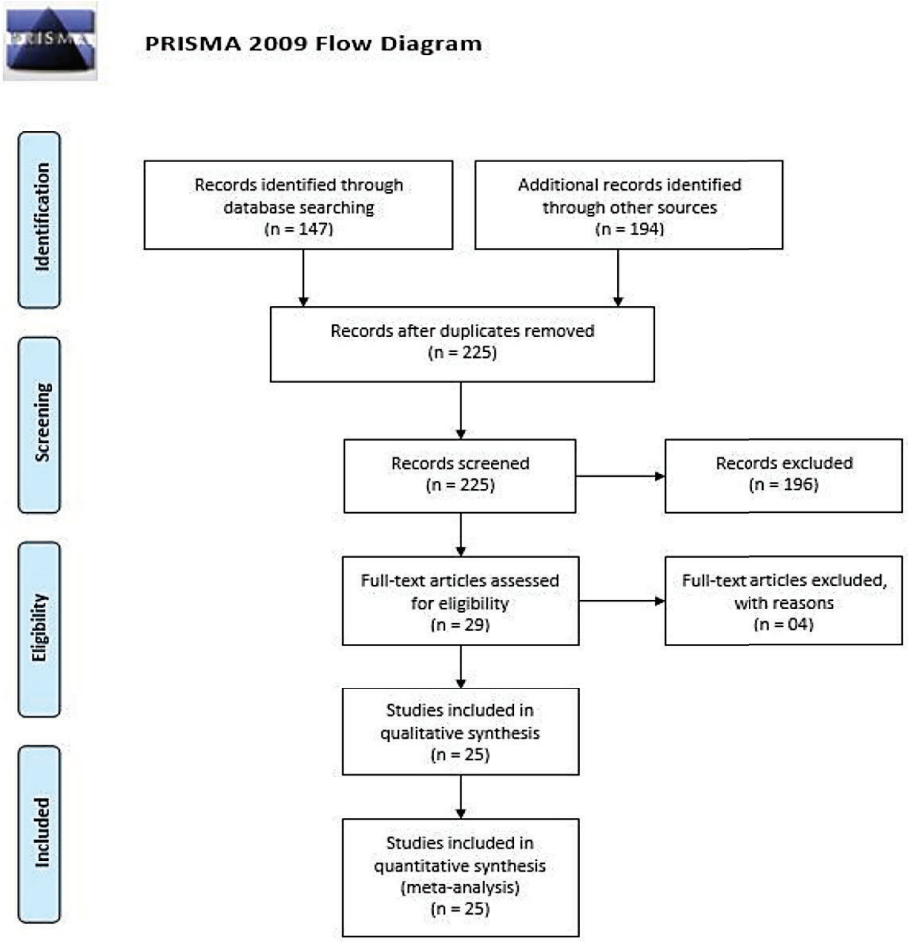

Fig.-1: *The systematic search revealed a total of 341 papers, of which 225 remained for review after duplicates were removed. After implementation of inclusion and exclusion criteria 29 articles were selected for full-text review. Following the full-text assessment of these articles, 25 studies remained for inclusion into the present study.*

Results

A total of 341 potential articles were identified from all databases (Figure 1). 25 studies included 7197 patients (2518 from BECAB, 672 for CCAB and 4007 with no assigned group) were selected following standard inclusion criteria for further analysis.

Quantity of evidence

The initial systematic search using our search strategy revealed a total of 147 published papers. An alternative search on The Ubiquity Partner Network (UPN) via Bangladesh Journal Online (BanglaJOL)[7] for published papers from Bangladesh revealed an additional 194 papers. After duplicates were excluded using Endnote X9 reference management software, 225 papers remained for further review.

Based on screening of titles and abstracts, irrelevant studies that did not satisfy our inclusion criteria were excluded, leaving 29 articles for full-text review. Following the full-text assessment of these articles, studies that lacked data on coronary revascularization surgery (n=4) were excluded, leaving 25 papers[11-35] for inclusion into the present study.

The PRISMA statement flow diagram shown in Figure 1 highlights the aforementioned screening process. We were aware that 4 studies from Ranjan et. al[20,24,33,35] and 2 studies each from Alam et. al[22,32] and Sazzad et. al,[18,27] all published in different years had been included in our meta-analysis as seen in Table 1. Assessment of the full texts verified that these studies were performed on completely different study populations, and were therefore included separately in our meta-analysis. To aid the identification of these papers, we made use of superscripted referencing throughout the present manuscript to properly distinguish the different publications.

Quality of evidence

From our risk of bias assessment of the included studies, we determined that 2 randomized controlled trials were associated with high risk of performance bias due to the outcome assessors not being blinded to the type of intervention[12,32] (Table-2). For the 14 prospective observational studies, [15,18-27,30,31,35] there was high risk of bias in confounding factors. The non-ramdomized clinical trials[11,14,16,28,34] were also significantly biased due to absence of randomization. Additionally, the bias in selection of patients was observed in retrospective studies[17,33] which is typical of studies that are retrospective nature. The included cross-sectional[13,29] studies were also devoid of comparative groups and thus had low significance to our study due to their small sample sizes. We determined that the evidence provided by these studies (and the included studies overall) was still of an acceptable quality (Table 1).

Of the 25 included studies, 5 were non-randomized clinical trail, 2 were retrospective cohort studies, 2 were randomized controlled trials, 2 were cross-sectional studies and 14 were prospective observational studies (Table 2). All studies were single-centre studies (Table 2).

Basic demographics and Preoperative characteristics

A majority of the CABG patients were male and 55 years old on average. The preoperative demographics analysis showed overall 62.48% patient had hypertension, 64.21% were smokers and 44.72% patients were diabetic. More diabetic and hypertensive patients were found in the BECAB group, while more smoker patients were in present in the CCAB group. However, these differences were statistically insignificant (Supplementary Table 2). Both groups were homogenous in terms of preoperative ejection fraction (EF), the number of NYHA –II/III patients and the number of patients with double vessel, triple vessel or left main coronary artery disease. The difference in incidence of preoperative stroke/ transient ischaemic attack (TIA) and MI between the 2 groups within 3 months of surgery was also insignificant.

Primary Outcomes

With the data from 5 studies and a total of 360 patients, we observed significantly lower operative times associated with BECAB as compared to CCAB (MD: -52.30, CI: -67.73 to -36.86, p<0.0001) (Figure 2A). There was no significant difference in the number of grafts used from 3 studies and 240 patients (MD: 0.15, CI: -0,54 to 0.84, p=0.67) (Figure 2B). There was also no significant difference in in-hospital mortality when data from 3 studies and 240 patients were compared (RR: 0.70, CI:0.22 to 2.25, p=0.55) (Figure 2C).

Secondary Outcomes

Comparing data from 3 studies and 180 patients, there was no significant difference in the rates of postoperative atrial fibrillation between the BECAB and CCAB groups (RR: 0.80, CI: 0.21 to 3.08, p=0.75) (Figure 2D). We observed shorter ventilation times associated with the BECAB group (MD: -8.64, CI: -9.47 to -7.82, p<0.0001) in

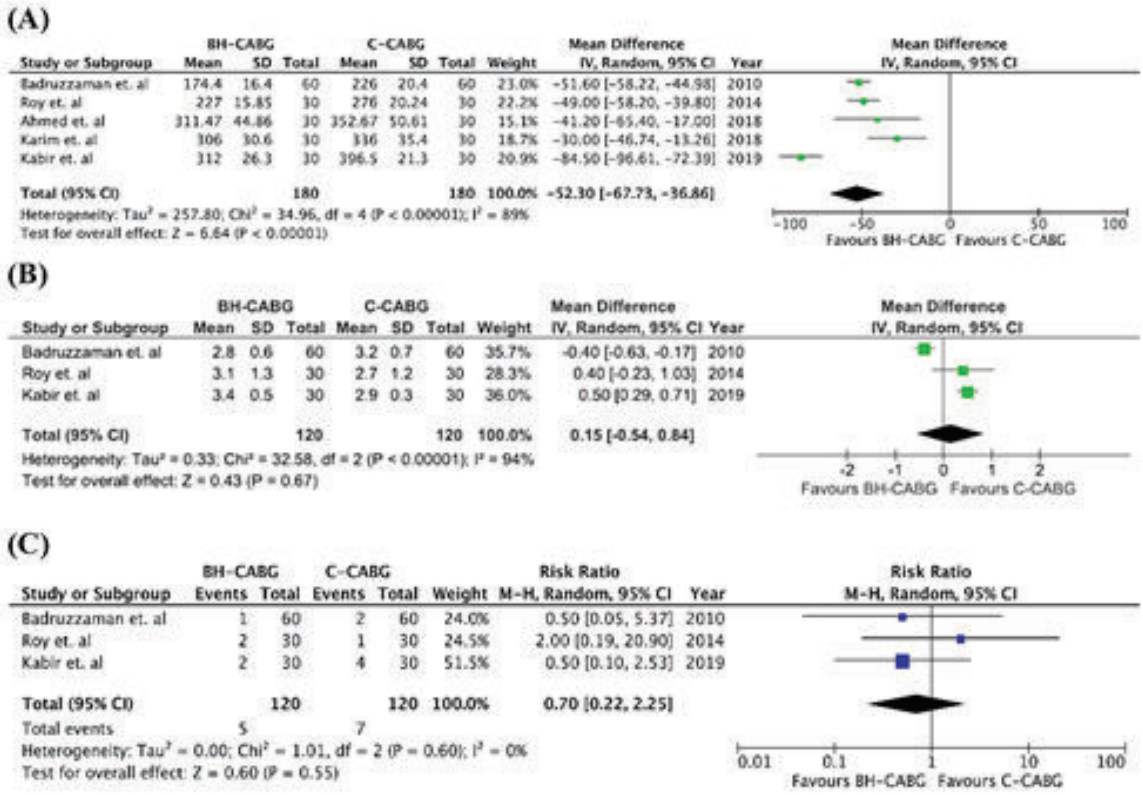

Fig.-2: *Forest plots showing (A) less operation time associated with BECAB, (B) no significant difference in the number of grafts used and (C) no significant in-hospital mortality.*

a pooled analysis of 5 studies and 360 patients (Figure 3E). With data from 5 studies and 400 patients, we also observed shorter ICU stays in the BECAB group as compared to the CCAB group (MD: -17.47, CI: -33.57 to -1.38, p=0.03) (Figure 3F). Finally, there were no significant differences in hospital stay between the groups when data from 3 studies and 180 patients were compared (MD: -0.41, CI: -2.79 to 1.98, p=0.74) (Figure 3G).

Analysis of Pooled Data

Our pooled analysis of 4 studies showed that the average blood loss for BECAB patients was 500.303 [352.099, 648.507] ml (I^2=99.62%, p<0.001). This was lower than the average blood loss for CCAB patients from 3 studies, which was 656.513 [453.537, 859.490] ml (I^2=99.68%, p<0.001). With data from 7 studies, the average incidence rate of perioperative MI for the BECAB group was 0.020 [0.002, 0.049] (I^2=80.00%, p<0.001), which was lower than that of the CCAB group at an average rate of 0.049 [0.015. 0.096] (I^2=42.56%, p=0.156). The pooled average rate of stroke or TIA for the BECAB group was 0.015 [0.000, 0.042] (I^2=63.84%, p=0.011), which was lower than that of CCAB group at an average rate of 0.081 [0.038, 0.136] (I^2=34.51%, p=0.191). The pooled average incidence rate of AKI with or without the need for dialysis was 0.006 [0.002, 0.012] (I^2=0.00%, p=0.543) for the BECAB group, which was lower than that of the CCAB group, with an average rate of 0.087 [0.055, 0.124] (I^2=0.00%, p=0.896). Pooled analysis of 6 studies showed that the average rate of respiratory complications in the BECAB group was 0.020 [0.000, 0.058] (I^2=70.65%, p=0.004), which was also lower than that of our pooled analysis of the CCAB group at a rate of 0.090 [0.043, 0.151] (I^2=18.41%, p=0.294). The rate of low output syndrome pooled from 2 studies was 0.123 [0.106, 0.141] (I^2=0.00%, p=0.369) for the BECAB group, while the pooled analysis of the CCAB group from 2 studies was 0.179 [0.108, 0.262] (I^2=0.00%, p=0.877). Finally, the average follow-up EF pooled from 5 studies for BECAB patients was 52.324 [48.200, 56.448] (I^2=98.64%, p<0.001), while pooled analysis of average EF of 3 studies for CCAB patients was 52.443 [42.097, 62.788] (I^2=99.68%, p<0.001) (Table 3).

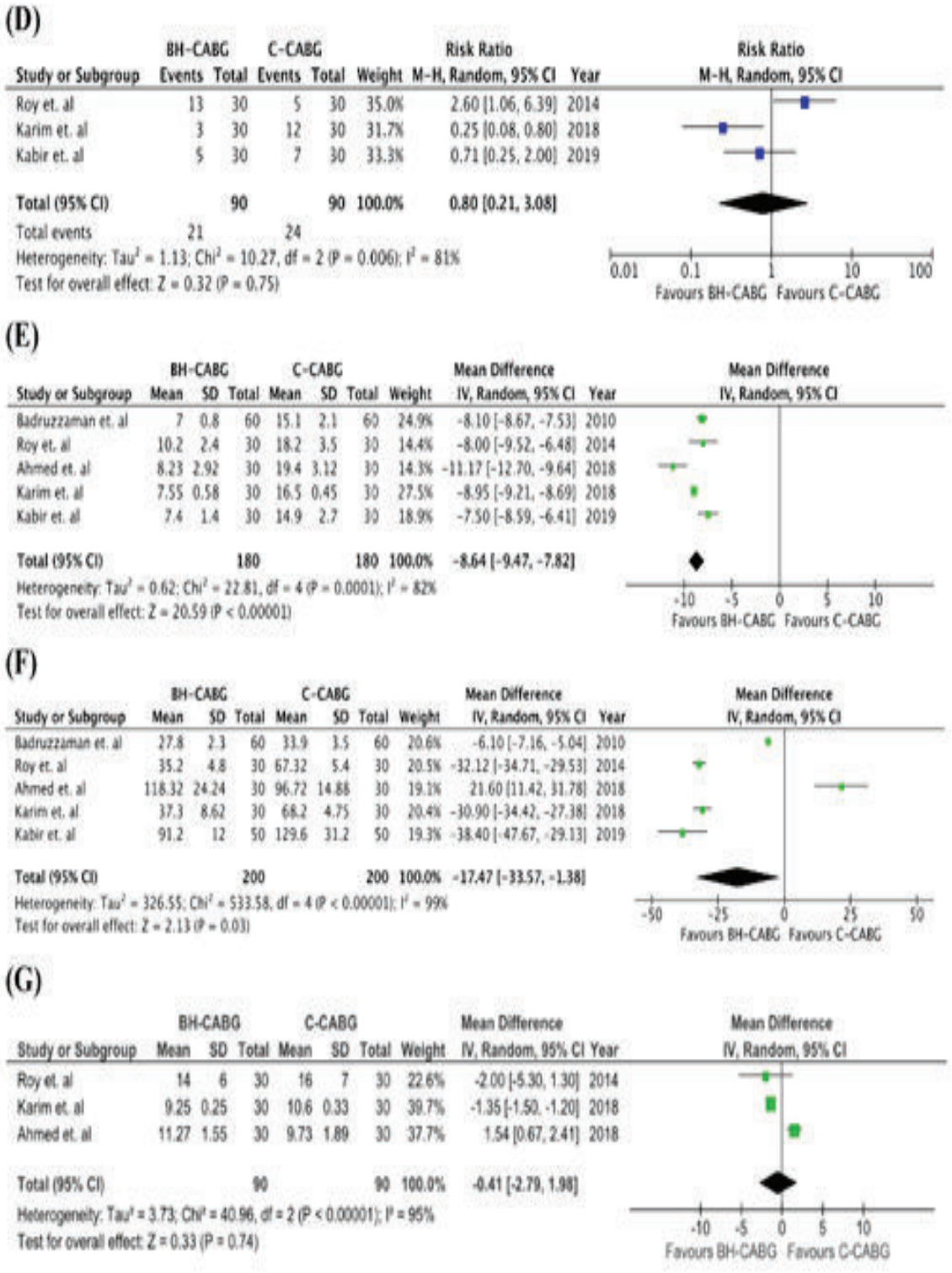

Fig.-3: *Forest plots showing (D) no significant difference in postoperative atrial fibrillation, (E) less ventilation time associated with BECAB, (F) shorter ICU stay associated with BECAB and (G) no significant difference in hospital stay.*

Table-III
Analysis of Pooled Data

Sl	Interest Variable	Study	BECAB	CCAB	Pooled Data
1	**Blood loss (ml)**	Roy et. al[12]	630.4±8.7	625.54 ±10.42	627.97 ±9.56
		Kabir et. al[16]	524.1±135.3	935.2±95.7	729.65±115.5
		Sazzad et. al[18]	475.92 ± 252.85	NA	475.92 ± 252.85
		R Karim et. al[21]	370.67±71.15	NA	370.67±71.15
		Hasan et. al[26]	NA	410.29±109.76	410.29±109.76
		Overall pooled	**500.303 [352.099, 648.507] I^2=99.62%, p<0.001**	**656.513 [453.537, 859.490] I^2=99.68%, p<0.001**	
2	**Perioperative MI (%)**	Roy et. al[12]	1.66	5	6.66
		Saydur el al[17]	3	NA	3
		M Begum et. al[19]	0	NA	0
		Ranjan et. al[20]	6.66	NA	6.66
		R Karim et. al[21]	6.25	NA	6.25
		Ranjan et. al[24]	3.35	NA	3.35
		Biswas et. al[25]	0	NA	0
		Hasan et. al[26]	NA	1.35	1.35
		J Alam et. al[28]	NA	6.35	6.35
		Ahsan et. al[30]	NA	8.33	8.33
		Overall pooled	**0.020 [0.002, 0.049] I^2=80.00%, p<0.001**	**0.049 [0.015. 0.096] I^2=42.56%, p=0.156**	
3	**Stroke/TIA (%)**	Roy et. al[12]	3.33	15	18.33
		Ahmed et. al[13]	6.7	0	6.7
		Kabir et. al[16]	0	8.7	8.7
		Saydur el al[17]	0	NA	0
		Ranjan et. al[20]	19.99	NA	20
		Salekin et. al[23]	0	NA	0
		Ranjan et. al[24]	0.81	NA	0.81
		J Alam et. al[28]	NA	11	11
		Ahsan et. al[30]	NA	5	5
		Overall pooled	**0.015 [0.000, 0.042] I^2=63.84%, p=0.011**	**0.081 [0.038, 0.136] I^2=34.51%, p=0.191**	
4	**Acute Kidney Injury with or without need for dialysis (%)**	Roy et. al[12]	3.33	6.66	10
		Kabir et. al[16]	3.7	13	8.35
		Saydur el al[17]	0.7	NA	0.7
		M Begum et. al[19]	2.5	NA	2.5
		Ranjan et. al[20]	6.66	NA	6.66
		Salekin et. al[23]	0	NA	0
		Ranjan et. al[24]	1.5	NA	1.5
		Sazzad et. al[27]	NA	7.92	7.92
		J Alam et. al[28]	NA	8.6	8.6
		Ahsan et. al[30]	NA	10	10
		Overall pooled	**0.006 [0.002, 0.012] I^2=0.00%, p=0.543**	**0.087 [0.055, 0.124] I^2=0.00%, p=0.896**	
5	**Respiratory complications (%)**	Roy et. al[12]	10	11.66	21.66
		Saydur el al[17]	0.7	NA	0.7
		M Begum et. al[19]	5	NA	5
		Ranjan et. al[20]	13.33	NA	13.33
		Salekin et. al[23]	0	NA	0
		Biswas et. al[25]	0.5	NA	0.5
		J Alam et. al[28]	NA	4.95	4.95
		Ahsan et. al[30]	NA	11.67	11.67
		Overall pooled	**0.020 [0.000, 0.058] I^2=70.65%, p=0.004**	**0.090 [0.043, 0.151] I^2=18.41%, p=0.294**	
6	**Low Output Syndrome (%)**	Roy et. al[12]	5	15	20
		Ranjan et. al[24]	12.95	NA	12.95
		Rahman et. al[29]	NA	18.57	18.57
		Overall pooled	0.123 [0.106, 0.141] I^2=0.00%, p=0.369	0.179 [0.108, 0.262] I^2=0.00%, p=0.877	
7	**Follow-up EF**	Badruzzaman et. al[11]	58.10±6.40	63.10±6.40	60.6±6.40
		Roy et. al[12]	46.26±2.01	42.9±1.7	44.58±1.85
		Kabir et. al[16]	51.6±2.8	51.4±2.9	51.5±2.85
		R Karim et. al[21]	55.34±3.97	NA	NA
		Salekin et. al[23]	50.46±5.06	NA	50.46±5.06
		Overall pooled	**52.324 [48.200, 56.448] I^2=98.64%, p<0.001**	**52.443 [42.097, 62.788] I^2=99.68%, p<0.001**	

Discussion:

BECAB is performed without the use of a heart-lung machine, thereby eliminating the need for placement of tubes, alternative artificial circulation and excessive manipulation of the aorta.[38] Despite these benefits, BECAB has its own set of challenges, particularly the difficulty that comes with operating on a constantly moving, blood-filled heart.[38] This has led to much discussion over the consequences of BECAB on patient outcomes and graft quality. Therefore, in our present study, we sought to perform a statistical evaluation of current literature reporting outcomes on BECAB, in order to discuss such concerns in an adult Bangladeshi CABG patient population.

From the results of our meta-analysis, we observed that there were significantly lower rates of operation time associated with BECAB as compared to CCAB. We speculate that this may present as a potential benefit of BECAB as evidence from previous studies have reported an association between longer operation times and higher risks of multiple organ dysfunction syndrome.[39] Longer operation times have also been shown to be significant predictors of mortality and morbidity.[40,41] Apart from shorter operation times, BECAB was also associated with shorter postoperative ventilation times and ICU stay. There were no significant differences in the number of grafts used, postoperative atrial fibrillation and hospital stay. This may suggest that the clinical outcomes of BECAB are non-inferior to, if not better than that of CCAB. Although, given the scarcity of papers that could be included in our meta-analysis, more research will be needed for any decisive conclusion to be made.

From our pooled analyses of patients in the BECAB cohort, we observed that the average blood loss was 500.303 [352.099, 648.507] ml, which was lower than that of the CCAB cohort. In addition, the average rates of perioperative MI (0.020 [0.002, 0.049]), stroke/TIA (0.015 [0.000, 0.042]), AKI (0.006 [0.002, 0.012]), respiratory complications (0.020 [0.000, 0.058]) and low output syndrome (0.123 [0.106, 0.141]) were all lower than the averages observed in the CCAB cohort. Once again, this may indicate that the clinical outcomes of BECAB may prove to be better than that of CCAB. However, once again we hesitate to conclude this with certainty due to the significant heterogeneity across the studies and between the groups, which made a direct statistical comparison between the average AEs of the BECAB and CCAB cohorts difficult.

In our meta-analysis, we observed high heterogeneity present in our comparisons of operation time, number of grafts, postoperative incidence of AF, ventilation time, ICU stay and hospital stay, as well as in the pooling of average blood loss, perioperative MI and follow-up EF. We determined that this could largely be attributed to the aforementioned differences in study design, as well as the presence of confounding factors.

A previous meta-analysis performed (published in 2016) comparing the clinical outcomes of BECAB patients with that of CCAB patients on high-risk patients outside the Bangladeshi population reported that BECAB was associated with lower early morbidly and mortality than BECAB, with lower rates of myocardial infarction, renal failure and low output syndrome.[42] Interestingly, we observed similar results in a specifically adult Bangladeshi population in our present meta-analysis. Our results could thus provide further evidence in support of the use of BECAB.

Other studies in literature have also suggested potential benefits of BECAB in reducing the risk of stroke, neurocognitive dysfunction, organ dysfunction, and atrial fibrillation,[43] as well as a low risk of mortality and/or complications in low risk patients.[38] These results were evaluated in the ROOBY trial,[44] which was carried out on 2203 patients. The trial observed no significant difference in 30-day mortality between the groups but did find higher rates of graft patency associated with BECAB.[44] There were also no differences in cognitive function at one year.[44] Hence, it appears that there is a general consensus that the clinical outcomes of BECAB are at least comparable to that of CCAB, which are consistent with our own observations. However, given the lack of research on a specifically Bangladeshi CABG population, more randomised controlled trials for this particular patient cohort comparing the clinical outcomes of BECAB and CCAB are needed in future to validate the results found in the present systematic review.

Conclusion:

In an adult Bangladeshi CABG population, BECAB was associated with shorter operation times, ventilation times and ICU stay as compared to CCAB. Additionally, we observed lower pooled average rates of perioperative MI, stroke/TIA, AKI, respiratory complications and low output syndrome in the BECAB cohort. At the very least, these results may suggest that the clinical outcomes of BECAB are non-inferior to that of CCAB. However, whether these clinical outcomes can be judged to be better than CCAB is a matter that requires more evidence from further research and data from randomized controlled trials.

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The Authors declare that there is no conflict of interest.

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