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ESTIMATION OF INTRA-OPERATIVE BLOOD LOSS DURING OFF PUMP CABG

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Abstract

Introduction

Patients with ischemic heart disease are on antiplatelet drugs or injectable heparin when referred for a coronary artery bypass grafting (CABG) surgery. Hence, they have an increased tendency for bleeding during the procedure. We conducted a study to estimate the actual amount of blood loss both during sternotomy and entire off-pump CABG procedure (OPCAB).

Methods

The present study was conducted in the accrual period between July 2017 till June 2019 at Sri Jayadeva Institute of Cardiovascular Sciences and Research, Bengaluru, enrolling 50 consecutive patients who fulfilled the inclusion criteria. Blood loss was estimated using gravimetric method by weighing the blood soaked mops and gauzes used during the entire procedure.

Results

The average blood loss during sternotomy and at the end of the CABG was estimated in 50 patients and it was found to be 294 ml and 797 ml respectively. Patients with left main coronary artery disease (LMCA) who were on intravenous heparin pre-operatively bled 6.3% more than non-LMCA patients who were only on aspirin prior to surgery. Patients who received 1 and 2 grafts bled 53% ($p \leq 0.0128$) and 5% ($p \leq 0.036$) lesser respectively than the average of the study population and statistically significant difference was found ($p \leq 0.001$). Patients who received 3 and 4 grafts bled about 4% and 16% respectively more than the average ($p \geq 0.01$).

Conclusion

Inevitable use of antiplatelet drugs and heparin in the pre-operative period increases blood loss during surgery. Subset of females, patients with LMCA disease and those who required 3 or 4 bypass grafts had a significantly increased amount of blood loss at the end of surgery in the study population.

Key words: *Blood loss during OPCAB, off pump CABG, Blood loss estimation*

Introduction

The coronary artery disease needs surgical intervention when the arteries have significant stenosis of >70%, have significant left main coronary artery disease of >50% stenosis, multi-segment and multi-vessel involvement with critically stenosed vessels not amenable for percutaneous interventions. Surgery can be done either on-pump or off pump if the distal targets are good in size and there is a viable myocardium to revascularize.[1] Off-pump coronary artery bypass grafting (OPCAB) is preferred by some surgeons to negate the adverse effects of cardiopulmonary bypass. Most of these concepts about CABG have been well researched through various trials and the

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present day protocols for the procedure have been evidence based decisions practised worldwide. Pre-operatively, all these patients are on dual antiplatelet medications. Patients with left main coronary artery disease are given intravenous unfractionated heparin or subcutaneous low molecular weight heparin 5 days pre-operatively, after stopping clopidogrel. These factors make them prone for excessive bleeding during the procedure. If this bleeding is left unattended, it eventually leads to hemodynamic instability, morbidity and death.[2] We conducted a study in patients undergoing CABG to estimate the actual amount of intra-operative blood loss during sternotomy and during off pump CABG procedure to understand the various factors that contribute to it. Literature search in Pubmed and Google scholar with key words 'blood loss during OPCAB' and 'effect of heparin and anti-platelet drugs in OPCAB' showed no published studies in Indian literature estimating the actual intra-operative blood loss during off pump CABG despite most of the surgeons here preferring the off pump method over the on-pump. Most studies published elsewhere estimated blood loss using serial hematocrit values, blood suctioned from operative field and post-operative drainage from intercostal drains.

Methods

During the study period between July 2017 to June 2019, we enrolled 50 consecutive patients who underwent off pump CABG in our unit at Sri Jayadeva Institute of Cardiovascular Sciences and Research, Bengaluru. The following Inclusion Criteria was employed: Patients undergoing off pump CABG; Exclusion Criteria were patients undergoing off pump CABG on conversion to on pump CABG, emergency CABG and patients with pre-existing coagulopathies. Patients were referred to us for surgery on having significant stenosis with multi-vessel and multi-segment involvement of coronary arteries where percutaneous interventions were not indicated. As per our institute protocol, all patients received dual antiplatelet drugs after coronary angiogram. After planning for surgery, clopidogrel was stopped at least five days prior to surgery. Patients with significant LMCA disease were started on intravenous heparin or low molecular weight heparin along with continuation of aspirin till a day prior to surgery.

Statistical Analysis

The sample size was determined based on the previous studies, inclusion with SD (2.56) and marginal difference of 10%. A total sample size of fifty was deemed adequate for the present study. The statistical analysis was performed using Statistical Package for the Social Sciences 16.0 version. Multivariate logistic regression was used. Continuous variables were expressed as mean ± standard deviation and categorical variables as frequency and percentages.

Procedure

Under general anesthesia, sternotomy is done. Left internal mammary artery (LIMA) and adequate length of saphenous vein are harvested. Sternotomy and harvesting of grafts were most often done by senior residents. Patients are then heparinised with intravenous heparin at 2 mg/kg to achieve a target ACT of > 300s. Bypass grafting is done by consultants in the unit as per protocol. All our patients receive a LIMA to left anterior descending artery (LAD) graft. Saphenous vein grafts are used to bypass the other stenotic lesions. At the end of the procedure, heparin is neutralised with protamine and adequate hemostasis achieved before closing the chest. Mops and gauzes used during the procedure are kept aside and weighed using a paediatric weighing scale [SALTER Model No 914]. Fluid used by the assisting nurse and assistant surgeons for irrigating the field to maintain a bloodless field and the amount of serosanguinous fluid suctioned out of the pericardial cavity into wall suction are also taken into account for calculations.

Calculation

Blood in the intravascular compartment is in a closed space which gets let out into the pericardial cavity at the site of arteriotomy, aortotomy or inadvertent injury to vascular or cardiac structures. This blood is diluted by the fluid squirted by the assisting nurse and the assistant surgeons into the operative field to keep it bloodless. Positioning the heart for doing distal anastamoses requires the use of large, folded mops to suitably orient the heart along with stabilisers and positioners like octopus and starfish. These wet mops soak up some amount of irrigating fluid and blood in the pericardial cavity and rest is suctioned out into wall suction. Mops and gauzes thus used are weighed using a paediatric weighing scale [Salter Model No 914] accurate upto two decimal points.

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It is presumed that 1ml of blood weighs 1mg; the specific gravity of red blood cells is 1.0293 as compared to that of plasma which is 1.0270. Thus, we arrive at these following equations

1. Blood loss during sternotomy = Weight of the large mops used during sternotomy - dry weight of the same mops prior use.

2. Blood loss at the leg end = Weight of the large wet mops (at the site of vein harvest) - dry weight of the same mops used at the leg end.

3. Total amount of blood loss during off pump CABG=

[{A – (B+C)} + Blood loss during sternotomy + Blood loss at leg end while harvesting vein

A: Serosanguinous fluid in the wall suction bottle;
B : Fluid from the mister-blower
C : Fluid squirted by the nurse and assistant surgeons into the operative field

Results

We collected data from 50 consecutive patients, who underwent off pump CABG in the accrual period from July 2017 to June 2019 at our institute. Average age of the study population was 60.6 years although the sample size varied between 44 –83 years. It had a predominantly male population as expected, with males constituting 76% (38 patients) of the study population. These 50 patients had multiple co-morbidities (Table 1). 31 of these patients(62%) were diabetic, 24 of them (48%) were hypertensive, 9 of them (18%) had a significant left main coronary artery disease and 8 of them (16%) had dyslipidemia. 14 patients (28%) were chronic smokers or tobacco chewers. 10 males and 4 females had both diabetes mellitus and hypertension, together constituting nearly a third of the study cohort.

Table 1. Demographic characteristics and its significance level of study population

Characteristics	Males (n=38)	odds	Females (n=12)	odds	Total (n=50)
Patients in the study population	38 (76%)	10.85 (p≤0.01)	12(24.0%) (p≤0.01)	3.55	50(100%)
Left main coronary artery disease	7(18.42%)	3.16 (p≤0.01)	2(16.66%) (p≥0.01)	<1	9 (18%)
Diabetes Mellitus	23(60.52%)	6.88 (p≤0.01)	8(66.66%) (p≤0.01)	1.22	31 (62%)
Hypertension	19(50%)	4.55 (p≤0.01)	5(41.66%) (p≥0.01)	<1	24 (48%)
Dyslipidemia	8(21.05%)	1.65 (p≤0.01)	0(%)	-	8 (16%)
Diabetes Mellitus+ Hypertension	10(26.31%)	2.22 (p≤0.01)	4(33.33%) (p≥0.01)	<1	14 (28%)
Smoking / Tobacco use	13(34.21%)	3.63 (p≤0.01)	1(8.33%) (p≥0.01)	<1	28 (56%)

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The main group was divided into many sub groups to understand the influence of various factors contributing to blood loss. In the entire study population, the average blood loss during sternotomy was 294 ml. The average blood loss at the end of the entire procedure was 797 ml which is inclusive of the blood lost during sternotomy. There were 38 males (76%) in this study and their average blood loss was similar to the average blood loss of the total study population. 12 female patients constituted about 24% of the study population and had higher amount of blood loss than that of the total study population with an average blood loss of 835 ml at the end of the procedure. They bled an average of 6% more than their male counterparts (Table 2).

Table 2. Average amount of blood loss among the males and females of the study population and also, comparison of blood loss between patients on injectable heparin + aspirin versus those on only aspirin last 5 days prior to surgery.

Characteristics	Number (n=50)	Average blood loss at sternotomy (ml)Mean ±SD	Total blood loss at the end of the procedure (ml) Mean ±SD	No of patients who required blood transfusion
Total study population	50	294±1.22	797±3.3	15 (30%)
Males	38 (76%)	286±1.89	785±3.87	11(28.6%)
Females	12(24%)	305±2.20	835±2.59	4 (33.3%)
Patients with LMCA disease(on injectable heparin +aspirin last 5 days pre-op)	09 (18%)	300±2.48	839±3.65	3 (33.3%)
Patients only on aspirin (last 5 days pre-op).Non-LMCA group	41 (82%)	292±5.55	787±4.02	12 (29.2%)

There were 9 patients (18%) with significant left main coronary artery disease and they had a higher amount of blood loss averaging 839 ml during the entire procedure. These patients were on injectable heparin and aspirin tablet last 5 days prior to surgery as per our institute protocol. Thus, these patients had greater tendency for bleeding. Patients who were only on aspirin tablet last 5 days preoperatively bled 6.6% lesser at the end of the procedure than those who were on both heparin and aspirin. Their average blood loss at the end of the procedure was 787 ml. Those groups which bled more showed increased requirement for blood transfusion as well in the immediate post-operative period. 15 patients (30%) out of the total study population required blood transfusion. Out of 38 male and 12 female patients, 11 males (29%) and 4 females(33.3%) respectively required blood transfusion. Patients who were on injectable heparin and aspirin 5 days prior to surgery had 4% increased blood transfusion rates as compared to those who were on only aspirin 5 days prior to surgery.

The study population was divided into four groups based on the number of grafts received (Table 3). Only two patients received a single graft and did not require any blood transfusion during surgery or in the immediate post-operative period. 19 patients received 2 grafts and only 1 (5%) of these patients needed blood transfusion. 23 patients received 3 grafts and 6 patients received 4 grafts. 10 patients(43%) in the 3 grafts group needed blood transfusion and 4 patients(66%) in the 4 grafts group were transfused blood. Of the 15 patients who received blood, 8 of them(53%) received it on the same day of surgery and rest of them were transfused on first or second post-operative day to correct low hematocrit. Most of these patients had co-existing diabetes mellitus, hypertension and dyslipidemia. None of these 50 patients had any re-exploration for bleeding, surgical site infections, sepsis or death.

Table 3 Blood loss across various groups based on the number of grafts

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Characteristics	Single graft	2 grafts	3 grafts	4 grafts
No. of patients in each group	2	19	23	6
Total blood loss (average) in ml at the end of surgery (mean ±SD)	389±1.66	757±2.58	830±6.33	930±4.98
No. of patients who had blood transfusion	0	1 (5%)	10 (43%)	4 (66%)
In comparison to average blood loss in total patients(797 ml)	-53%	-5%	+4%	+16.6%
p-Value	≤0.0128	≤0.036	≥0.01	≥0.01

As expected, with the increase in the number of grafts received, the amount of blood lost also increases when compared to the average loss in the total study population. Patients who received a single graft bled 53% ($p \leq 0.0128$) lesser than the average blood lost in the total cohort. Those who received 2 grafts bled 5% ($p \leq 0.036$) lesser. However, those who received 3 and 4 grafts bled considerably more at 4% ($p \geq 0.01$) and 16.6 % ($p \geq 0.01$) more than the average blood loss of the study population. The post-operative haemoglobin levels showed a drop by about 3 g/dL in most of the patients. Despite having a high threshold for transfusion, 30% of patients (11 males and 4 females) required blood transfusion in the post-operative period to achieve a target haemoglobin level of about 9 g/dL before being discharged. All CABG patients in our institute are restarted on dual antiplatelet drugs as soon as the post-operative bleeding becomes minimal.

Discussion

Blood loss during off pump CABG is a contribution of multiple factors like platelet abnormalities, use of injectable heparin in the pre-operative period, plaqued targets causing difficulty in placing intracoronary shunts and in performing anastomoses, more number of stenotic lesions that require to be bypassed, inadequate hemostasis and inadvertent vessel injuries that are unmasked by hypertension.[3] Platelet function is of importance to minimise blood loss and achieve hemostasis. Pre-operatively, all patients are on dual anti-platelet drugs. Clopidogrel if used within 4 days prior to surgery is known to cause significant bleeding during the procedure, increase blood transfusion rates and causes higher chances of re-exploration for bleeding post-surgery.[4] However, studies have documented that aspirin that acts by blocking the cyclo-oxygenase pathway enhances bleeding tendency only slightly and doesn't affect the transfusion rates.[5] Estimation of blood loss during any surgical procedure is important to know in order to minimise its loss or to alter factors that may cause its increase. Blood loss is dependent on the type of procedure, duration of procedure and the dexterity of the surgeon. Minimising blood loss during and after the procedure is important to negate the untoward consequence of blood transfusions that may occur in some patients like febrile reactions, sepsis, immunosuppression and viral transmissions.[6] More the blood transfusions, more is the morbidity, length of hospital stay and mortality; apart from escalating cost for patients and the blood banks.[6] There are many methods to assess blood loss. Subjective visual estimation, weighing the swabs, dye method, calorimetric method, measuring blood collected in the suction apparatus, radio-isotopes and red cell tagging.[7] Radiometric method uses radioactive-tagged red blood cells to assess the blood loss. This is a fairly accurate method but time consuming and expensive.[7] Most surgeons and anesthetists, over a period of time, begin to rely on subjective visual estimation, although, its not at all a reliable method since it often underestimates the actual blood loss.[8] Calorimetric method converts the haemoglobin to acid haematin to compare it to known standards of calorimeter. Due to gross errors, this is no longer used. Gravimetric method is a popular method. Advocated initially by Wangensteen, it involves weighing the blood stained gauzes and mops and subtracting their dry weight. 1 ml of blood is presumed to weigh about 1 mg. Blood from suction canisters can be measured to assess the loss. However, they are most often diluted with fluids squirted into the operating field to keep it bloodless and clear. Gravimetric method is simple, inexpensive and easy to use.[9] Calculation method uses predetermined

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mathematical formulae incorporating blood volume along with pre-operative and post-operative hematocrit levels to calculate estimated blood loss after centrifuging the sero-sanguinous effluent in the suction canisters from the operative field. However, in the operating room, this is a cumbersome process.[9] A recent method is the Triton system. It involves capturing images of blood soaked mops, gauzes and suction canisters in a tablet computer (iPad) which calculates the actual blood loss using complex algorithms accurately.[10] We used the gravimetric method, taking into account the amount of blood lost in suction canisters and hemodilution in the operative field. Vitello DJ and et al have proved in their study that the density of blood is nearly equal to that of water, validating the gravimetric method.[11] We found that factors like female gender, left main coronary artery disease and requirement of 3 to 4 grafts increased the propensity for blood loss. Blood can be lost in the intra-operative or immediate post-operative period. Corresponding to this blood loss, we found that the average haemoglobin levels in our study population dropped by 3g/dl post surgery. This drop in haemoglobin levels would stabilise after post-operative day 3. Literature review also shows that the peripheral blood parameters will gradually recover in the post-operative period and reach their pre-operative levels by 1-3 months following surgery.[12] Nelson et al have demonstrated in their study that post surgery, there is a decrease in the blood volume, red blood cell volume and plasma volume by 18%, 38% and 8% respectively. They concluded that fall in the hematocrit is due to decrease in the red blood cell volume post-surgery and not hemodilution.[13] Severe anaemia in the post-operative period is associated with many unfavourable consequences. In severe anaemics, for every 1.0 g/dL drop in haemoglobin level in the post-operative period, there is a 13% increase in cardiovascular events and a 22% increase in the all-cause mortality following CABG.[14] 30% of our study population underwent blood transfusion in the intra-operative or immediate post-operative period to achieve a haemoglobin level of 9 g/dL before we discharged them. Additionally, oral iron supplements were added to their diet. Having slightly lower haemoglobin levels is better during the initial few days of post-operative period to keep the blood less viscous, ensuring better circulation at edematous anastamotic sites and hence lessening the chances of graft occlusion due to blood clotting. Our study has its limitations. It is a single centre study and sample size is small. Though patients were operated by the same surgical team in our study, incorporating multi-centre data would be beneficial to estimate the average blood loss across many centres.

Conclusion

Pre-operative inevitable use of antiplatelet drugs and heparin increases bleeding tendency during CABG procedure. Our study found that female gender, left main coronary artery disease and requirement of 3 or 4 bypass grafts resulted in greater amount of total blood loss and increased blood transfusion requirements after surgery. Correlating with this, we found an average drop in the haemoglobin level by 3g/dL after surgery in our study cohort.

Tables:

Table 1 : Demographic characteristics of the study population.

Table 2 : Average amount of blood loss among both males and females of the study population and also, comparison of blood loss between patients on injectable heparin +aspirin versus those on only aspirin last 5 days prior to surgery.

Table 3 : Blood loss across various groups based on the number of grafts received.

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Informed consent from all patients was obtained prior to the surgery

By submitting this manuscript, each author certifies that: They made a direct and substantial contribution to the work reported in the manuscript by participating in at least the following areas: made substantial contributions to conception and design and/or acquisition of data and/or analysis and interpretation of data; participated in drafting and/or revising the paper and provided important intellectual contributions; and gave final approval of the submitted version and any revised versions submitted prior to acceptance. They participated to a sufficient degree to take public responsibility for the work and believe that the manuscript describes truthful facts. Each author also agrees to allow the corresponding author to make decisions regarding submission of the manuscript to the Journal, changes to galley proofs, and prepublication release of information in the manuscript to the media, federal agencies, or both. If requested by the editors, we are willing to share the data on which the manuscript is based for examination by editors.

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