

## Prevention of Peri-operative Cardiac Tamponade for Bleeding after C.A.B.G: Risk Factors, Outcomes and the Effect of Left Partial Pericardiotomy and Early Re-exploration

Hassan Mir Mohammad Sadeghi\*

Rajaie Cardiovascular Medical and Research Center,  
Iran University of Medical Sciences, Tehran, Iran.

<http://dx.doi.org/10.13005/bbra/2383>

(Received: 31 October 2016; accepted: 08 November 2016)

We sought to determine whether Partial Left Pericardiotomy (PLP) and early re-exploration add incremental values in preventive Pericardial Tamponade (PT) in post coronary artery bypass surgery patients. We aimed to identify risk factors for pericardial tamponade for bleeding after surgical revascularization in our practice. In all, 20000 consecutive patients undergoing only CABG between March 1, 2004 to May 30, 2015 were retrospectively analyzed from our cardiac surgery data base registry. Multivariate logistic regression analysis was based to identify risk factors for pericardial tamponade (PT) after bleeding to assess the effect of partial left pericardiotomy (PLP), pericardial tamponade patients were Propensity matched as with unique patients having PLP done in them routinely. Also results of early timing re-exploration in CABG's were analyzed. A total number of 625 patients out of 20016 CABG cases underwent re-exploration for pericardial tamponades (PT) Multivariate analysis revealed that by not opening the left pleural space it significantly increased the risks of tamponade. Propensity matched analysis showed that preoperative opening of left partial pericardiotomy into left pleural space were associated with decreased risk of cardiac tamponade in patients undergoing Open Heart Surgery whether on-pump or off-pump. There was a significant difference in the mortality rate. Adverse outcomes were significantly higher when patients waited more than 12 hours after the end of operation and return to the ICU for re-exploration due to bleeding post operatively. One of the greatest risk factors for re-exploration for bleeding after open heart surgery is cardiac tamponade and delay in re-exploration. Patients in need of re-exploration are at higher risk of complications if we have not opened up the left pleural space via partial left pericardiotomy and if the time of re-exploration is delayed. Policies that promote opening up left pleural space and prompt early return to the operating room for re-exploration should be encouraged.

**Keywords:** Partial Left Pericardiotomy (PLP); Pericardial Tamponade (PT); Coronary Artery Bypass Grafting (CABG); Intra-Aortic Balloon Pump (IABP).

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By improvement in both surgical and percutaneous revascularization techniques, the treatment of coronary artery disease has evolved and excellent results have appeared.

These patients with a chronic stable Angina need not worry since almost all will be managed by medical therapy, however those in

need of coronary artery bypass surgery or percutaneous coronary intervention will be of our interest, especially those undergoing surgery<sup>(1)</sup>. One of the greatest risk post operatively is cardiac tamponade. And in order to prevent or minimize cardiac tamponade we strongly recommend doing partial left pericardiotomy incision to relieve the heart post operatively of any pressure effect that the blood or clots may exert.

### Methods

We followed the cases of a surgeon with

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\* To whom all correspondence should be addressed.

routine partial pericardiectomy during an eleven year follow up on his 3200 cases of CABG and compared with the rest of his colleagues at a large Metropolitan 600 bed Heart Center in Tehran, Iran with about 20016 cases of CABG from March 1, 2004 to May 30, 2015.

The data were collected retrograde by our cardiac surgery registry (Table I, II). Those cases undergoing CABG at our hospital, irrespective of the use of CPB, are fully heparinized, namely, receiving 300 unit per-kilogram body weight of heparin, irrespective of whether they are having on-pump or off-pump surgery. All those cases of having mitral valve surgery and or repair, resection of a ventricular aneurysm or other surgical procedure along with CABG's were excluded and some detail methods of collecting data have been described in detail by Wynne-Jones<sup>6</sup>.

The primary outcome measure of our study was re-exploration for cardiac tamponade, which was deferred as collection of clot and bleeding that required surgical re-exploration after arriving at I.C.U from open heart surgery. The decision to take patient back to O.R. was made by cardiac surgical fellow responsible based on the protocol promulgated by Kirklin and Barrat-Boyes<sup>7</sup> and table III. Although slight modification has been made regarding the patient's vital signs.

The criteria are as follows: <sup>1</sup> drainage of more than 500 ml. during the first hour, more than 400 ml. during each of the first 2 hours, more than 300 ml. during each of the first 3 hours, or more than 1000ml. in total in the first 4 hours<sup>2</sup> obvious signs of cardiac tamponade;<sup>3</sup> sudden massive bleeding;<sup>4</sup> excess bleeding despite correction of coagulopathies<sup>5</sup> and cardiac arrest in a patient who continues to bleed.

The results that were collected after re-exploration for cardiac tamponades and bleeding are listed in table 4. All patients that were followed especially for sternal wound infections were in accord with the published evidence-based guidelines by the Center for Disease Control and Prevention (CDCP)<sup>(8)</sup>.

Also a group leading by Kuvin JT<sup>(2)</sup> analyzed retrospectively 4561 consecutive patients undergoing open heart surgery, and those with clinical suspicion of pericardial effusion following surgery were further evaluated by transthoracic or trans esophageal echocardiography and only 48

(1%) had evidence of moderate or large pericardial effusion of whom 37 (74%) had evidence of pericardial tamponade (PT). Of course only 24% of above cases had CABG while the rest had some valvar involvement such as valve replacement or repair. He reported one in hospital death due to pericardial tamponade (PT).

So he concluded that pericardial tamponade following open heart surgery was more common with any valvar manipulation along with CABG<sup>(2)</sup>.

A patient with CAD has atheromatous lesions in his coronaries, impeding blood flow to his cardiac muscles. Therefore by doing bypass surgery it will supply extra flow to the region.

Now one of the complication post operating is bleeding. Approximately 30 percent of patients require a blood transfusion after CABG. Patients with heavy bleeding that requires reoperation often need multiple blood transfusions and may stay longer in the intensive care units.

Only about 2 percent of those will require surgery to stop excessive bleeding<sup>(3)</sup>.

One factor that increases the risk of bleeding post CABG is taking aspirin prior to surgery. Plavix (Clopidogrel) and ibuprofen are generally discontinued for several days prior to coronary surgery. Those on warfarin should consult their surgeon prior to surgery<sup>(3)</sup>.

Other study by Floerchiger et al<sup>(4)</sup> revealed a bigger pool of patients in need of surgical intervention for cardiac tamponade. A total of 12 cases (44%) out of 25 patients after open heart surgery were taken for surgical intervention for bleeding. By using CT imaging as a supplemental procedure provided a rapid diagnostic reliability in patients with delayed cardiac tamponade since diagnostic accuracy of transthoracic echocardiography is limited in patients after open heart surgery<sup>(4)</sup>.

There was a case of late cardiac tamponade of about 400 days post-operatively that drained 1350 ml in total. This 48 year old male had undergone quadruple CABG, with history of three episodes of near fainting and collapsed after taking his evening dose of Atenolol 50mg. There was no history of trauma. An echocardiogram showed some fluid, so by catheter drainage some 750 ml serosanguin fluid was drained with difficulty and some improvement was achieved. Yet in day two,

again the echo revealed more re-accumulation of fluid around posterolateral aspect of left ventricle and further 200 mls of blood were aspirated. On day four more than 400ml was shown and it was evacuated manually. So on day seven patient recuperated well and new echo data showed

**Table 1.** Heart Hospital Registry

		Percent Patient (Number)	Percent R-exploration for Bleeding(Number)	P value
Age at operation (years)	<60	36 (7200)	3 (216)	0.158
	60-70	53 (10609)	3.4 (361)	
	70+	11 (2202)	4 (88)	
Sex	Female	20 (4003)	3.8 (152)	0.248
	Male	80 (16013)	2.9 (464)	
Diabetes	No	71 (14211)	3.0 (426)	0.281
	Yes	29 (5805)	3.5 (203)	
Renal Dysfunction	No	97.2 (19456)	3.1 (603)	0.764
	Yes	2.8 (560)	2.5 (14)	
Prior Cardio logical Intervention	No	95 (19015)	3.2 (608)	0.217
	Yes	5 (1001)	1.4 (50)	
Ejection Fraction <30%	No	91.9 (18395)	3.0 (552)	0.767
	Yes	8.1 (1621)	3.4 (55)	
Three-vessel Disease	No	19.5 (3903)	2.8 (109)	0.713
	Yes	80.5 (16113)	3.1 (50)	
Left Main Disease >50%	No	79.3 (15873)	3.3 (524)	0.239
	Yes	20.7 (4143)	2.3 (95)	
Priority of Surgery	Elective	82 (16413)	2.6 (427)	0.021
	Urgent (as soon as possible)	16.6 (3323)	4.8 (160)	
	Emergency	1.4 (280)	7.5 (21)	
Re-Do Cardiac Surgery	No	97.4 (19496)	3.1 (604)	0.837
	Yes	2.6 (520)	2.7 (14)	

**Table 2.** Procedural techniques

	Percent patients	Percent Re-exploration for Bleeding (Number)	P value
Use of CPB			
No	12 (2402)	2.6 (62)	0.341
Yes	88 (17614)	3.3 (581)	
CPB (duration)			
<60 min	3.6 (721)	2.1 (15)	0.856
<120 min	84 (16813)	3.2 (538)	
>150 min	12 (2402)	3.5 (84)	
Cross-clamp duration			
<60 min	82 (16413)	3.2 (525)	0.739
>60 min	18 (3603)	3.5 (126)	
Use of LIMA			
No	8 (1601)	1.5 (24)	0.136
Yes	92 (18414)	3.2(589)	
Number of Grafts			
<2	14 (2802)	2.6 (73)	0.224
3	48 (9007)	2.9 (261)	
>4	41 (8207)	4 (328)	

**Table 3.** Chest Drainage Criteria for Reoperation

Preoperative Weight (kg)	Chest Drainage Indicating Reoperation				
	Hourly Amount (ml. h <sup>-1</sup> ) No. of Successive Hours <sup>a</sup>			Total Amount (ml) Hour No. <sup>b</sup>	
	1	2	3	4	5
5.0	70	60	50	120	130
6.0	70	60	50	130	155
7.0	70	60	50	150	180
8.0	90	70	50	175	200
9.0	90	80	60	195	230
10.0	100	90	65	220	260
12.0	130	100	80	260	300
14.0	150	120	90	300	360
16.0	170	140	100	350	400
18.0	195	150	120	390	460
20.0	200	175	130	450	520
25.0	270	220	160	540	650
30.0	325	260	195	650	770
35.0	380	300	230	760	900
40.0	430	350	260	800	1.035
45.0	500	400	300	975	1.050
50.0	500	400	300	1.000	1.200

<sup>a</sup> Reoperation is advisable if the patient has bled the amount indicated in any 1 hour (column 1), the lesser amount in column 2 during each of any 2 successive hours, or the still smaller amount (Column 3) in each of any 3 successive hours. <sup>b</sup> Reoperation is advisable, if by the end of the fourth or fifth postoperative hour, the patient has bled in total the amount indicated.

**Table 4.** Outcomes in propensity- Matched Groups

	Re-exploration for Tamponade and bleeding(n=74)	Control(n=625)	P value
Mortality (%)	1.3 (1)	3.6 (23)	0.031
Sternal Wound Infection (%)	9.5 (7)	4.8 (30)	0.023
Renal Failure (%)	9.5 (7)	2.4 (15)	0.312
IABP support (%)	38 (28)	2.4 (15)	<0.001
Mechanical support >24 hrs (%)	32 (24)	23 (144)	0.461

ICU: Intensive care unit; IABP=Intra aortic Balloon pump

**Table 5.** Propensity-Matched Groups of Patients

	Re-exploration for Tamponade and bleeding(n=74)	Control(n=625)	P value
Age at operation (years)	56	58	0.331
Female Sex (%)	24 (18)	28 (175)	0.596
Re-Do Surgery (%)	2 (1)	3.6 (23)	0.321
Left main D2 >50%	10 (7)	13 (81)	0.816
Three vessel D2 (%)	83 (61)	79 (494)	0.691
Renal dysfunction (%)	1.4 (1)	3.6 (23)	0.312
Diabetes	22 (17)	17.6 (110)	0.621

ICU: Intensive care unit; IABP=Intra aortic Balloon pump

minimal residual fluid there. Patient left the hospital on day 9. A total of 1350 ml were aspirated<sup>(5)</sup>.

Now if we had the pericardial wall opened all the way to near left phrenic nerve bundles, we would have avoided this collection of fluid around the heart and would have avoided catastrophic outcomes. We have clearly demonstrated these good results at our center by analyzing the database available (Shahid Rajaie Heart Data Base, Tehran, Iran), Table IV.

Hospital mortality was defined as death within the same hospital admission regardless of cause. Renal failure was defined as rise of creatinin above 1.5 (Creatinin level greater than 200 mmol/L) or Patients requiring dialysis.

Another way of obtaining a safe and good results post CABG is early re-exploration for bleeding. We at Shahid Rajaie Heart Hospital have developed a protocol of early re-exploration of post CABG cases once the total drainage reaches of about 1000 ml.

Some factors affect our decision for early re-exploration post operatively, namely having a rare blood group, an unstable hemodynamics even as getting massive doses of ionotropes, and finally deranged lab data especially on coagulations such as INR, prothrombin, Partial Thromboplastin Time (PTT) and number of platelets.

Patients requiring re-exploration for bleeding and tamponade were propensity-matched with those cases of bleeding in need of exploration,

yet had not partial left pericardiectomy done. To do this, logistic regression<sup>(9)</sup> was used to develop a propensity score for re-exploration for early bleeding for all patients of CABG whether or not they had partial pericardiectomy<sup>(10)</sup>. The propensity score was constructed using all the variables listed in table V.

Patients re-explored were matched with those not having PLP who had our identical 5-digit propensity score. If this could not be done, we would reduce one score each time, until it matched<sup>(11, 12)</sup>.

## RESULTS

Overall, of the 3200 patients 74 were re-explored while in those of 20016 cases about 625 were taken to OR to control bleeding and clot removals.

The incidence of re-exploration has increased from 2.1% in those with partial left pericardiectomy (PLP) to almost 3.3% in those cases not doing it.

Of 74 cases of re-exploration following PLP, the primary indication was bleeding (66).

Other indications were 8 tamponade and 2 cardiac arrests. The major sites of bleeding were as follows: 38 were graft/anastomosis, 30 sternal/left internal mammary artery bed, 4 extra-pericardial, and 2 were cannulation sites.

The median time to take patient to

**Table 6.** Multivariate Risk Factors for Tamponade and bleeding re-exploration

Risk Factors	Odds Ratio	95% Confidence Intervals	P value
Nonelective surgery	1.8	1.1 to 2.8	0.022
Number of grafts	1.7	1.1 to 3.0	0.035
Age of operation	1.03	1.01 to 1.05	0.041

**Table 7.** Time to Re-exploration and postoperative outcomes

	Hours to Re-exploration		
	<6	6-12	12+
Mortality (%)	0	0	2.3 (2)
Sternal Wound Infection (%)	3.6 (2)	4.1 (3)	3.8 (3)
Renal Failure (%)	0	0	9.5 (7)
Mechanical support >24 hrs (%)	8 (5)	9 (5)	21 (15)
IABP support (%)	10 (7)	12 (8)	18 (13)

ICU: Intensive care unit; IABP=Intra aortic Balloon pump

operating room was 8.5 hours after arrival at I.C.U and median blood loss was 1480 ml before re-exploration. 6 patients required more than one re-exploration.

The results of multivariate logistic regression analysis (Table VI) showed that non-elective surgery ( $P=0.022$ ) and more grafts ( $P=0.035$ ) and finally increased age ( $P=0.041$ ) were all independent predictors of re-exploration for bleeding and tamponades.

It is worth to mention that no association was found between re-exploration for bleeding and preoperative aspirin and heparin use in off-pump CABG, although for on pump CABG cases had higher proportion of re-exploration by those on Aspirin ( $P=0.004$ ) and aspirin/heparin ( $P=0.001$ ).

The relation between the time for re-exploration for bleeding and post operative outcomes are shown in Table VII.

### CONCLUSION

We believe that most cases of bleeding after open heart surgery have a surgical cause, and hence, there is a stronger recommendation for early exploration of those patients who continue to bleed after coming to I.C.U. Also most studies have found increased risk in older patients, longer CPB times, greater number of distal anastomosis, dialysis dependent renal failure and the use of internal mammary artery<sup>(13-16)</sup>.

So one of the greatest risk factors for re-exploration for bleeding after open heart surgery is cardiac tamponade and delay in re-exploration. Patients in need of re-exploration are at higher risk of complications if we have not opened up the left pleural space via partial left pericardiectomy to allow space for blood and clots to drain into left pleural space therefore relieve the heart of possible pressure effect of clots and therefore prevent a catastrophic tamponade and if the time for re-exploration is delayed.

We strongly urge the in-house policies that promote opening up the left pleural space via partial left pericardiectomy to near the left phrenic nerve and also prompt return to the operating room for re-exploration for bleeding.

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