# Does opening the pleura during internal mammary artery harvesting decrease the risk of tamponade?

*İnternal meme arteri çıkarılırken plevranın açılması tamponad riskini azaltır mı?*

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***Background:*** In this study we investigated the effect of opening the pleura on the rates of early postoperative bleeding and/or cardiac tamponade.

***Methods:*** The clinical data of 2110 patients who underwent coronary artery bypass grafting (CABG) between January 2007 and September 2009 in our clinic were retrospectively evaluated with regard to opening of pleura and development of tamponade. Sixty-six patients (3.1%) who required reoperation due to early postoperative bleeding and/or tamponade were identified.

***Results:*** Similar rates of emergency revision (2.9% versus 3.2%, respectively; p=0.85) and tamponade (1.8% versus 1.3%, respectively; p=0.46) were observed among patients with opened pleura (n=46) and intact pleura (n=20). Among the subset of patients who required early reoperation for bleeding/tamponade, tamponade was present in 12 patients (60.0%) with intact pleura compared to 18 patients (39.1%) in whom pleura was opened (p=0.178). Development of tamponade was associated with an increased total drainage, increased time to reoperation, prolonged duration of intubation and increased use of inotropic agents.

***Conclusion:*** Opening the pleura during CABG for internal mammary artery harvesting does not decrease the incidence of tamponade. Although larger studies are required, leaving the pleura intact may be the preferred option in most CABG patients.

*Key words:* Coronary artery bypass grafting; internal mammary artery harvesting; intact pleura; opening the pleura; tamponade.

***Amaç:*** Bu çalışmada plevranın açılmasının erken ameliyat sonrası kanama veya kardiyak tamponad gelişimi sıklığı üzerindeki etkisi incelendi.

***Çalışma planı:*** Ocak 2007 - Eylül 2009 tarihleri arasında kliniğimizde koroner arter bypass greftleme (KABG) ameliyatı uygulanan toplam 2110 hastanın klinik verileri plevranın açılması ve tamponad gelişimi açısından geriye dönük olarak incelendi. Erken ameliyat sonrası kanama veya tamponad nedeniyle tekrar ameliyatına alınan 66 hasta (%3.1) tespit edildi.

***Bulgular:*** Plevranın açıldığı (n=46) ve açılmadığı (n=20) hastalardaki acil revizyon (sırasıyla %2.9 ve %3.2; p=0.85) ve tamponad oranları (sırasıyla %1.8 ve %1.3; p=0.46) benzerdi. Kanama/tamponad nedeniyle erken tekrar ameliyatı uygulanması gereken hasta alt grubunda, plevrası açılmayan hastaların 12'sinde (%60), açılanların ise 18'inde (%39.1) tamponad vardı (p=0.178). Tamponad gelişimi toplam drenaj miktarında, tekrar ameliyatına kadar geçen sürede, mekanik ventilasyon süresinde ve inotropik ajan kullanımındaki artışla ilişkiliydi.

***Sonuç:*** Koroner arter bypass greftleme sırasında internal meme arterinin çıkarılması için plevranın açılması tamponad sıklığını azaltmamaktadır. Daha büyük çalışmalara ihtiyaç duyulmasına karşın, KABG hastalarının çoğunda plevranın korunması tercih edilecek seçenek olabilir.

*Anahtar sözcükler:* Koroner arter bypass greftleme; internal mamariyal arter çıkarılması; plevra korunması; plevra açılması; tamponad.

The use of the internal mammary artery (IMA) as a conduit for coronary artery bypass grafting (CABG) is superior to venous grafts in terms of long-term graft patency, lower incidence of cardiac events and short and long-term outcomes.[1] However, the use of the IMA for CABG might be associated with increased incidence of early postoperative bleeding and/or cardiac tamponade.[2] The reported incidence

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of postoperative bleeding and/or cardiac tamponade requiring re-exploration in patients undergoing CABG surgery is between 2% and 6%.[2-3] In these subjects, postoperative cardiac tamponade might increase morbidity and mortality.[4] Although opening mediastinal pleura during IMA harvesting is generally thought to prevent pericardial tamponade, this assumption was evidenced in only one study[5] and therefore further studies are needed.

Basically, there are three different techniques used to harvest the IMA: pedunculated IMA, skeletonization[6] and semiskeletonization (a technique which does not necessitate lateral incision of endothoracic fascia for skeletonization).[7] Although opening the pleura during IMA harvesting is at the discretion of the operating surgeon, it is usually practiced more frequently in skeletonization or semiskeletonization approaches. There are some potential advantages and disadvantages of opening the pleura during IMA harvesting. The potential advantages include prevention of cardiac tamponade,[5] better exposure, prevention of tension that may occur with expansion of the lungs and closure of the sternum, and prevention of damage to the IMA during reoperations.[4] The potential disadvantage is the increased incidence of postoperative pulmonary complications as shown in a number of studies.[5,8]

The aim of this study was to investigate the effect of keeping the pleura intact during IMA harvesting on the occurrence of early postoperative bleeding and/or cardiac tamponade and to examine the characteristics of the patient subset with cardiac tamponade.

## PATIENTS AND METHODS

### Patients

Among a total of 2110 subjects who underwent elective, isolated CABG operation with IMA harvesting between January 2007 and September 2009, sixty-six patients (3.1%) required early reoperation due to early postoperative bleeding and/or tamponade. Of the 678 patients with intact and 1432 patients with opened pleura (depending on the method used during IMA harvesting), 20 (2.94%) and 46 (3.21%) were re-explored for preoperative diagnosis of bleeding and/or tamponade, respectively. Data of this subset of patients requiring early revision were analyzed. In addition to the comparison of the overall rates for revision and tamponade among all subjects (n=2110) with regard to intact versus opened pleura, the same parameters and other clinical features were compared among patients requiring early re-exploration due to bleeding/tamponade. The characteristics of patients with or without cardiac tamponade were also compared.

### Surgical technique

Following general anesthesia and median sternotomy, the IMA was harvested using semiskeletonization approach in all patients. After application of an IMA elevator, the table was raised and tilted to the left. The mediastinal pleura was dissected gently from the endothoracic fascia. An incision was made in the medial side of the endothoracic fascia with electrocautery. After exploration of the IMA and vein medial to it, the IMA was dissected from the thoracic wall and from endothoracic fascia with low voltage electrocautery. Hemoclips were applied to the IMA branches and in the majority of cases the accompanying vein and adipose tissue were dissected from the IMA with electrocautery. After administration of heparin, the IMA was cut at the level of the 6$^{th}$ intercostal space before its bifurcation. The distal end of the IMA was clamped with a bulldog clamp and external papaverine was applied.

In the group of patients with opened pleura, a tunnel was created with incision of proximal pericardium until the phrenic nerve (to prevent shift of the left IMA to midline and to prevent damage to the left IMA during re-explorations). In the group with intact pleura, to prevent the shift of the left IMA, the proximal part of pericardium was partially incised and suspended from the thoracic wall (pericardial flap) and in majority of the patients the tunnel was created by incising the adipose tissue over the pleura.

In the group with intact pleura, a 36 F semi-rigid straight tube (Bıçakçılar Thoracic Catheter, Flared End, Straight, Bıçakçılar, İstanbul, Turkey) was placed in the mediastinum. In the other group, an additional 36 F semi-rigid angulated thoracic tube (Bıçakçılar Thoracic Catheter, Flared End, Angled, Bıçakçılar, İstanbul, Turkey) was placed through the subxiphoid space over the diaphragm. If the right pleura was also opened, 36 F semi-rigid angulated thoracic tubes were placed through the same route to the right thorax. Just after admission to the intensive care unit, the tubes were continuously aspirated with negative pressure of 20 cm $H_2O$. Postoperatively, nurses routinely performed hourly milking and stripping of the tubes. In all patients, chest X-rays were routinely obtained at the first postoperative hour and the amount of drainage and hemodynamic parameters were recorded every hour.

None of the patients had increased prothrombin times or liver dysfunction preoperatively. All patients with use of anti-aggregating drugs (acetylsalicylic acid, clopidogrel) were operated on after a five-day drug free period. We did not use aprotinin in any of these patients. Tranexamic acid was used in 24 patients (10 in the pleura intact and 14 in the open pleura group).

### Indications of re-exploration for bleeding

Each of the following was an indication for re-exploration: *(i)* drainage of >500 ml during the first hour, >400 ml/hour during first two hours, >300 ml/hour during first three hours, or more than 1000 ml in total during the first four hours; *(ii)* subtle, continuous bleeding throughout the first 12 hours, leading to a total bleeding exceeding 100 ml/hour; *(iii)* sudden massive bleeding; *(iv)* obvious signs of cardiac tamponade.

### Diagnosis of tamponade

The following findings were considered as indicative of cardiac compromise: Hypotension, oliguria, worsening base deficit/acidosis, increasing right atrial (RA) pressure, increasing tachycardia and arterial pulsus paradoxus. All patients were routinely screened with chest X-ray on the first operative hour. In cases with excessive drainage and suspicion of cardiac tamponade, the X-ray was repeated and a third X-ray was obtained in some of the cases. Increase in cardiothoracic index on the second and third X-rays compared to the initial image was accepted as a supporting finding for the diagnosis of tamponade. Echocardiographic features of tamponade sought in addition to the presence of a pericardial fluid collection included RA systolic collapse, right ventricular (RV) diastolic collapse, a swinging heart, and an enlarged, non-pulsatile inferior vena cava. In addition, features that varied excessively with the respiratory cycle were noted, including changes in ventricular size, transmitral and trans-tricuspid flow velocities, and the presence of arterial paradox from aortic Doppler recording.

Re-exploration of all patients was performed in the surgical room. None of the patients were delivered to the surgical room under critical conditions such as cardiac arrest or with cardiac massage. During exploration the presence or absence of cardiac tamponade was documented to establish a surgically confirmed diagnosis. In order to make such a diagnosis, parameters such as blood pressure, RA pressure and tachycardia had to be improved upon removal of blood and coagulum. The amount of evacuated blood and/or coagulum was recorded in patients with tamponade. Bleeding foci were also recorded.

### Statistical analyses

NCSS (Number Cruncher Statistical System) 2007 & PASS (Power Analysis and Sample Size) 2008 Statistical Software (NCSS, Kaysville, Utah, USA) was used for analysis of data. Besides descriptive statistics (mean ± standard deviation, median, and frequency), Student's t test or Mann-Whitney U-test were used for the comparison of quantitative data depending on the normality of the distribution; and for the comparison of categorical data, Chi-square or Fischer's exact tests were used where appropriate. The statistically significant difference was denoted with a p value $<0.05$.

## RESULTS

### Patients

Among 2110 patients screened for the study, 20 out of 678 (2.9%) patients with intact pleura required early re-exploration compared to 46 out of 1432 (3.2%) patients with opened pleura (p=0.85). The frequencies of cardiac tamponade were 1.8% (12/678) and 1.3% (18/1432) for patients with and without intact pleura, respectively (p=0.46). Thus, no significant differences exist in the rates of emergency revision for bleeding/tamponade and tamponade between the two groups of patients. In patients with tamponade, 320 ml of blood and/or coagulum was evacuated (range 140-600 ml) in average during the reoperations.

### Comparison of patients requiring revision with regard to open versus intact pleura

Tamponade was present in 12 out of 20 cases (60.0%) with intact pleura compared to 18 out of 46 cases (39.1%) in the open pleura group (p=0.178). These two groups of patients were not significantly different in terms of demographical, clinical, operative and postoperative characteristics including total amount of drainage (Table 1). Five of these tamponade cases were caused by collections in the posterior surface of the heart (2 in the intact pleura and 3 in the open pleura group). The rate of mediastinitis (0% and 2.2% for intact and opened pleura groups, respectively, p=1.0), need for inotropic agents (50.0% and 43.5%, p=0.63) or intra-aortic balloon pump (IABP; 0% and 8.75%, p=0.31), and mortality rates (0% and 4.3, p=1.00) were similar for the two groups. In nine patients with opened pleura, accumulation of blood was evident in the pleural cavity during reoperation (mean 420 ml, ranged, 300-700 ml). Tranexamic acid was used in 24 patients (10 in pleura intact and 14 in open pleura group) and 13 of these patients [4 (20%) in the pleura intact and 9 (19.6%) in the open pleura group, p=0.901] had tamponade in the follow-up.

### Comparison of patients with and without cardiac tamponade

Clinical findings of tamponade were as follows: Hypotension (n=28; 22 requiring inotropic support), increase in tachycardia (n=24), worsening base deficit/acidosis (n=22), pulsus paradoxus (n=15), oliguria (n=10), increased RA pressure (n=12), tachypnea (n=2). Twenty-six patients required repeat X-ray examination to demonstrate the increase in cardiothoracic index. Transthoracic echocardiography was performed on 24 patients and tamponade was

**Table 1. Characteristics of patients requiring early revision with regard to intact and opened pleura**

| Parameter | Intact pleura (n=20) | | | | Opened pleura (n=46) | | | | *p* |
|---|---|---|---|---|---|---|---|---|---|
| | n | % | Mean±SD | Median | n | % | Mean±SD | Median | |
| Demographical characteristics | | | | | | | | | |
| Age, (year) | | | 62.2±9.4 | 67 | | | 61.6±9.3 | 63 | 0.813 |
| BMI, (kg/m$^2$) | | | 24.4±2.5 | 25.1 | | | 25.3±3.4 | 24.7 | 0.242 |
| Male gender | 19 | 95.0 | | | 37 | 80.4 | | | 0.129 |
| Clinical and operative characteristics | | | | | | | | | |
| Number of grafts | | | 3.8±1.2 | 4 | | | 3.6±0.9 | 4 | 0.629 |
| On-pump CABG | 18 | 90.0 | | | 42 | 91.3 | | | 1.000 |
| Blood transfusions, (unit) | | | 4.4±1.8 | 4.5 | | | 4.8±1.2 | 5 | 0.313 |
| Use of tranexamic acid | 10 | 50 | | | 14 | 30.4 | | | 0.102 |
| Postoperative characteristics | | | | | | | | | |
| Total drainage, (ml) | | | 1262.5±543.8 | 1200 | | | 1279.4±438.1 | 1000 | 0.894 |
| Duration of intubation, (hour) | | | 18.1±4.7 | 18 | 1 | | 8.8±6.9 | 18 | 0.847 |
| ICU stay, (day) | | | 1.6±0.8 | 1 | | | 2.9±3.8 | 2 | 0.058 |
| Hospital stay, (day) | | | 6.7±1.8 | 6 | | | 7.7±0.4 | 7 | 0.124 |
| Creatinine, (mg/dl) | | | 1.1±0.3 | 0.99 | | | 1.4±0.7 | 1.2 | 0.069 |
| Time to reoperation, (hour) | | | 8.1±6.0 | 5.5 | | | 7.8±6.2 | 5.5 | 0.844 |
| Tamponade | 12 | 60.0 | | | 18 | 39.1 | | | 0.178 |

Unless otherwise stated, data are expressed as mean ± SD. BMI: Body mass index; CABG: Coronary artery bypass grafting; ICU: Intensive care unit; SD: Standard deviation.

confirmed in 14 (58%). The total amount of drainage from drains (1423.9±605.9 ml versus 1150.0±262.4, p=0.017) and the total amount of blood transfusion required (5.4±1.3 U versus 4.0±1.2 U, p=0.001) were higher among patients with cardiac tamponade. On the other hand, in six patients with tamponade, the total amount of drainage was relatively small (<800 ml) and in two other patients' tamponade developed later after the operation (>4 days). Initial emergency operation was more frequent among patients with tamponade (13.3% versus 0%, p=0.038) and the time to reoperation was significantly prolonged (11.0±7.0 hrs versus 5.3±3.7 hrs, p=0.001), compared to patients without tamponade. In addition, cardiac tamponade was associated with prolonged duration of intubation (19.4±41 hrs versus 17.9±7.6 hrs, p=0.014) and increased use of inotropic agents (73.3% versus 22.2%, p=0.001). On the other hand, rates of mediastinitis (0% versus 2.8%, p=1.00), IABP use (10% versus 2.8%, p=0.323) and mortality (3.3% versus 2.8%) was similar. The two groups did not also differ in terms of other demographical, clinical and operative characteristics investigated during the study (Table 2).

## DISCUSSION

The association between opening the pleura during IMA harvesting in CABG surgery and the incidence of postoperative pericardial tamponade is not scientifically well documented. Practice and theory suggest that opening of pleura may prevent the occurrence of cardiac tamponade, despite the lack of sound scientific evidence to confirm this assumption. If intact pleura is a contributing factor for the occurrence of tamponade, it may be assumed that postoperative morbidity and mortality will increase in such cases.[4] On the other hand, keeping the pleura closed during IMA harvesting is expected to lead to a decreased incidence of pulmonary complications.[5] The aim of the present study was to help clarify this controversy.

Literature review revealed only one study in which the association between pleural continuity and pericardial tamponade was documented. This study analyzed the 280 cases and reported that five out of 130 cases with intact pleura were re-explored due to bleeding and cardiac tamponade as compared to six out of 150 cases with opened pleura that were re-explored due to bleeding wherein no cardiac tamponade was documented.[5] This study suggested that opening the pleura prevents pericardial tamponade, although the small sample size limits the extrapolation of these results to all cases. By comparison, our study included a larger sample size and no significant differences were found in the incidence of cardiac tamponade between the two groups, when all screened patients or the subset of patients requiring early revision for bleeding/tamponade were analyzed. It has been reported that opening the pleura may help to decrease the incidence of cardiac tamponade but cannot provide absolute protection.[5] In our study, among cardiac tamponade cases with opened pleura, the expansion of the lung prevented the drainage from mediastinum to thoracic cavity, and collection of blood and coagulum

**Table 2. Comparison of patients with or without cardiac tamponade**

| Parameter | Tamponade present (n=30) | | | | Tamponade absent (n=36) | | | | *p* |
|---|---|---|---|---|---|---|---|---|---|
| | n | % | Mean±SD | Median | n | % | Mean±SD | Median | |
| Demographical characteristics | | | | | | | | | |
| Age, (year) | | | 62.4±8.7 | 60 | | | 61.3±9.7 | 63 | 0.623 |
| BMI, (kg/m$^2$) | | | 24.7±2.7 | 24.6 | | | 25.3±3.5 | 26.8 | 0.453 |
| Male gender | 28 | 93.3 | | | 28 | 77.8 | | | 0.097 |
| Clinical and operative characteristics | | | | | | | | | |
| Number of grafts | | | 3.9±1.1 | 4 | | | 3.5±0.9 | 3.5 | 0.105 |
| On-pump CABG | 28 | 93.3 | | | 32 | 88.9 | | | 0.681 |
| Blood transfusions, (unit) | | | 5.4±1.3 | 5 | | | 4.0±1.2 | 4 | 0.001 |
| Use of tranexamic acid | 13 | 43.3 | | | 11 | 30.6 | | | 0.256 |
| Emergency operation | 4 | 13.3 | | | 0 | 0 | | | 0.038 |
| Postoperative characteristics | | | | | | | | | |
| Total drainage, (ml) | | | 1423.3±605.9 | 900 | | | 1150.0±262.4 | 1200 | 0.017 |
| Duration of intubation, (hour) | | | 19.4±4.1 | 19 | | | 17.9±7.6 | 16 | 0.014 |
| ICU stay, (day) | | | 2.6±3.8 | 2 | | | 2.4±2.7 | 1 | 0.634 |
| Hospital stay, (day) | | | 7.0±1.9 | 6 | | | 10.2±10.4 | 7 | 0.351 |
| Creatinine, (mg/dl) | | | 1.4±0.9 | 1.2 | | | 1.2±0.3 | 1.1 | 0.327 |
| Time to reoperation, (hour) | | | 11.0±7.0 | 10 | | | 5.3±3.7 | 4 | 0.001 |

Unless otherwise stated, data are expressed as mean±SD. BMI: Body mass index; CABG: Coronary artery bypass grafting; ICU: Intensive care unit; SD: Standard deviation.

(even 140 cc) at the posterior of the heart in particular may be the cause of cardiac tamponade in these cases. Contrary to the classical pericardial tamponade manifesting itself with global excessive fluid during the late post cardiac surgery period, lesser volumes of localized blood and coagulum may lead to pericardial tamponade in these cases and the clinical and echocardiographic signs of tamponade may be absent.[6] In our study, the average volume of blood and coagulum drained surgically during re-exploration was 320 cc, which was smaller compared to the volume reported for late cases of tamponade, and transthoracic echocardiography documented the presence of tamponade in 58% of the subjects.

In the literature, the reported incidence of post-CABG re-exploration for bleeding or tamponade ranges from 2% to 6%.[2,3] Of these re-explored patients, tamponade was present in 6-67% cases.[2,9] In our study, 3.1% of the cases were re-explored and 45% of these patients had tamponade.

Bleeding and/or tamponade occurring after CABG surgery may be associated with a number of factors.[2-7] The efficiency of mediastinal drainage tube may also play a role, since coagulum inside or around the tube may plug the drainage and with continuing bleeding tamponade may ensue. The number and type of the tubes and effective manipulation of tubes by the postoperative care team might help to alleviate such problems. Recently, silastic flexible tubes have been introduced to substitute the conventional large, tube-shaped, semi-rigid tubes. Although some studies suggested a beneficial effect in preventing tamponade with tubes located posterior to the heart,[10,11] other studies did not confirm this finding.[12,13] On the other hand, many studies showed that posterior pericardiotomy is an effective procedure for the prevention of postoperative tamponade and pericardial effusion.[14,15] To prevent blockade in chest tubes, and possible tamponade, nurses apply different methods of manipulation including milking, stripping, fanfolding and tapping. No differences have been reported between the manipulations.[6]

In our study, comparison of cases with and without tamponade point to several factors that may be associated with an increased risk of tamponade. There were significant differences in the time to re-exploration, the volume of drainage and the rates of emergency reoperation. In particular, time to initiate re-exploration emerged as a significant factor (11 hrs in patients with tamponade versus 5.27 hrs in patients without, p=0.001). A study by Choong et al.[9] also supports this finding where the incidence of tamponade was higher in cases that underwent re-exploration after 12 hours [<12 hrs, 12% (157/19) versus >12 hrs, 44% (34/15)].

Pericardial tamponade as a result of significant drainage is associated with increased morbidity and mortality in the early post-CABG period. In our study, cases with tamponade had prolonged intubation, and higher

requirements for transfusion and inotropic use. The first two parameters are related to late reoperation and not to tamponade per se. No difference in other parameters predicting the clinical course was observed (i.e. duration of stay in ICU, creatinine level, IABP, mediastinitis, non-microbial dehiscence, duration of hospitalization). Based on these findings from a limited number of patients, one may speculate that adverse consequences of tamponade may not be as severe as expected.

Basically, there are three techniques for harvesting of the IMA: pedunculated harvesting, skeletonization[6] and semiskeletonization.[7] Although opening the pleura during IMA harvesting is at the discretion of the operating surgeon or the institution, skeletonization or semiskeletonization harvesting techniques are more likely to be associated with opening the pleura.[12,16] There are some pros and cons of opening the pleura during IMA harvesting. The potential advantages are prevention of cardiac tamponade,[5] better exposure, prevention of possible tension occurring with expansion of lungs and closure of sternum, and prevention of damage to IMA during reoperations.[4] The potential disadvantages include the increased incidence of postoperative pulmonary complications as shown in a number of studies.[5,8] Also more blood loss and increased pain,[12] prolonged intubation and prolonged hospital stays[16] were reported. In our study, despite the lack of difference between the two groups in terms of the number of patients requiring postoperative intensive pulmonary care, nine patients with opened pleura had significant collection of blood and coagulum in the pleural space.

The main purpose of opening the pleura during IMA harvesting is to achieve better surgical exposure, to prevent tension of the IMA with expansion of lungs, to prevent shift of the IMA to midline, and to prevent damage during reoperations rather than the prevention of tamponade.[4] But the same advantages may be achieved with intact pleura by suspension of proximal pericardium from the thoracic wall,[17] and placement of the IMA under the lung with a pericardial and pleural incision.[18]

The main limitation is the retrospective nature of the study. A randomized controlled study will give less biased results. Inclusion of only re-operated patients with or without opened pleura may be considered as a limitation to our study. This fact was the main reason why we did not make a multivariate analysis. Also, ideally serial echocardiographic measurements could have been made to assess the volume of pericardial effusions. However, the low sensitivity of transthoracic echocardiography in the diagnosis of tamponade should be kept in mind.

In conclusion, in this sample of patients, opening the pleura during CABG for left IMA harvesting did not decrease the incidence of tamponade. Thus, our results do not support the belief that that opening the pleura is superior to the opposite practice. Given the potential risks of pulmonary complications, leaving the pleura intact during harvesting may be the preferred option in most CABG patients. However, further studies with larger numbers of patients are warranted to draw firmer conclusions.

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