Prevalence and Clinical Course of Pleural Effusions at 30 Days after Coronary Artery and Cardiac Surgery

Richard W. Light, Jeffrey T. Rogers, J. Phillip Moyers, Y. C. Gary Lee, R. Michael Rodriguez, William C. Alford Jr., Stephen K. Ball, George R. Burrus, William H. Coltharp, David M. Glassford Jr., Steven J. Hoff, John W. Lea IV, Jonathan C. Nesbitt, Michael R. Petracek, Thomas D. Starkey, William S. Stoney, and Mark Tedder

Departments of Medicine and Surgery, Saint Thomas Hospital and Vanderbilt University, Nashville, Tennessee

The present prospective study was designed to determine the prevalence of pleural effusion at approximately 28 days after cardiac surgery and their subsequent course. This consecutive case study included 389 patients; 312 had only coronary artery bypass graft surgery (CABG) surgery, 37 had both valve and CABG surgery, and 40 had only valve surgery. Chest radiographs were obtained approximately 28 days postoperatively. Patients were subsequently contacted by telephone 3, 6, and 12 months postoperatively and questioned about the presence of fluid in their chest and related symptoms. The prevalence of pleural effusions in the patients undergoing only CABG surgery (63%) or CABG surgery plus valve surgery (62%) was significantly ($p = 0.05$) higher than that in the patients undergoing valve surgery only (45%). The prevalence of effusions occupying more than 25% of the hemithorax was 9.7%. The primary symptom associated with these larger effusions was dyspnea. Chest pain and fever were uncommon. Over the 12-month follow-up, the effusions tended to resolve. In conclusion, the prevalence of pleural effusions occupying more than 25% of the hemithorax is approximately 10%, 28 days postoperatively. These larger pleural effusions produce dyspnea but not chest pain or fever, and most of the effusions disappear gradually over the subsequent months.

Keywords: pleural effusion; coronary artery bypass graft surgery; Dressler's syndrome; dyspnea

At least 40% of patients who undergo coronary artery bypass graft surgery (CABG) develop a pleural effusion in the immediate postoperative period (1–6). Most of the effusions are small and left-sided. The natural history of these effusions is that the majority resolve and do not result in patient morbidity. However, in an occasional patient, the effusion persists or a new effusion develops within the first few months postoperatively (7, 8). The prevalence of these larger pleural effusions and their natural history is largely unknown.

The objectives of the present prospective study were as follows: (*1*) to determine the prevalence of pleural effusions 28 days after cardiac surgery, (*2*) to determine if the prevalence of pleural effusion was related to the type of cardiac surgery (CABG only versus CABG plus valve surgery versus valve surgery only), (*3*) to compare the prevalence of pleural effusion in those patients receiving only saphenous view graft (SVG) versus those who also received internal mammary artery (IMA) grafts, (*4*) to determine whether any operative factors were associated with the presence of a large effusion, and (*5*) to determine the natural history of the effusions present at 28 days. We hypothesized that the prevalence of large (occupying > 25% hemithorax) pleural effusions would be approximately 5%, that prevalence of pleural effusions would be greatest in those patients who underwent both CABG and valve replacement, that the prevalence of pleural effusions would be higher in those patients who received IMA grafts, and that the larger pleural effusions present at 28 days would likely be persistent.

METHODS

Saint Thomas Hospital is a tertiary care hospital in which more than 2,000 CABG surgeries are performed annually. The present study was a prospective study in which patients were enrolled between August 25, 1997 and April 30, 1998. None of the patients in the present study were included in previous studies (7, 8) on pleural effusions after CABG from this institution. The study was approved by the Institutional Review Board of Saint Thomas Hospital, and all patients signed a written informed consent. Patients who participated in the study had a posteroanterior and lateral chest radiograph when they returned for their regular follow-up visit 3 to 5 weeks postoperatively. The radiographs as well as the preoperative radiographs were reviewed simultaneously by two of the authors (J.P.M. and R.M.R.) who arrived at a consensus grade for the size of the effusion on each side according to the criteria in Table 1. The size of the effusion was estimated on the lateral radiograph by visually estimating the percentage of the area of the hemithorax that was occupied by pleural fluid as described previously (7). In this paper, pleural effusions occupying more than 25% of the hemithorax are defined as *large*, whereas all other pleural effusions are defined as *small*.

Attempts were made to contact all patients by phone at 3 and 6 months after CABG surgery. In addition, attempts were made to contact the patients with large effusions 12 months after CABG surgery. During the phone follow-up, patients were asked if they knew whether they had any fluid in their chest, whether they had received a thoracentesis or any other treatment for their pleural effusion, and whether they were suffering from shortness of breath, pleuritic chest pain, or were experiencing fever.

The hospital maintains a database for all patients who undergo cardiac surgery. The characteristics of the patients who did and did not have pleural effusions were compared. The particular characteristics that we analyzed included the patient's age, sex, and the number and type of bypass grafts. Regarding the surgery, we analyzed whether the patients received antegrade or retrograde cardioplegia, and the operative times.

Statistical Analysis

The data are expressed as the mean ± SD if normally distributed, and the median with the 25th and 75th percentiles if not normally distributed. The frequency of pleural effusions in the different groups was compared using Chi-square analysis. The characteristics of the patients with no effusion, small effusions, and large effusions were compared using one-way analysis of variance.

RESULTS

A total of 602 patients signed informed consents for the study. Of these, 213 did not return or were not sent for the follow-up chest radiograph at their return visit and are excluded from further analysis. Of the remaining 389 patients who returned for

(*Received in original form March 7, 2002; accepted in final form September 9, 2002*)

Supported in part by Saint Thomas Foundation, Nashville, TN.

Correspondence and requests for reprints should be addressed to Richard W. Light, M.D., Director of Pulmonary Disease Program, Saint Thomas Hospital, P.O. Box 380-4220 Harding Road, Nashville, TN. E-mail: RLIGHT98@yahoo.com

Am J Respir Crit Care Med Vol 166. pp 1567–1571, 2002
Originally Published in Press as DOI: 10.1164/rccm.200203-184OC on October 11, 2002
Internet address: www.atsjournals.org

TABLE 1. SEMIQUANTITATION OF SIZE OF PLEURAL EFFUSIONS

Grade of Effusion	Characteristic of Chest Radiograph
0	No pleural fluid present
1	Blunting of the costophrenic angle
2	More than blunting of the costophrenic angle but less than 25% of hemithorax occupied by pleural fluid
3	Pleural fluid occupying 25–50% of hemithorax
4	Pleural fluid occupying 51–75% of hemithorax
5	Pleural fluid occupying more than 75% of hemithorax

TABLE 2. PREVALENCE OF PLEURAL EFFUSIONS ON CHEST RADIOGRAPHS OBTAINED APPROXIMATELY 30 DAYS AFTER CARDIAC SURGERY

	CABG Only (*n = 312*)	Valve + CABG (*n = 37*)	Valve Only (*n = 40*)
Effusion present	196 (62.8%)	23 (62.2%)	18 (45.0%)*
No effusion present	116 (37.2%)	14 (37.8%)	22 (55.0%)

Definition of abbreviation: CABG = coronary artery bypass graft.
* $\chi^2 = 4.03$, $p = 0.045$.

the chest radiograph, 312 had CABG surgery only, 37 also had concurrent valve replacements, and 40 underwent only valve replacement.

A high prevalence of pleural effusions was present on the chest radiographs obtained approximately 4 weeks postoperatively (Table 2). The prevalence of pleural effusion in the 312 patients who underwent CABG surgery only was 62.4%, which was virtually identical to the prevalence of pleural effusion in the 37 patients who underwent both CABG and valve surgery (60.5%). The prevalence of pleural effusion in the patients who underwent only valve surgery (45.0%) was significantly less than the prevalence of pleural effusion in the patients who underwent CABG surgery ($\chi^2 = 4.03$, $p = 0.045$).

Most of the pleural effusions in the patients who underwent CAGB surgery were either unilateral on the left or larger on the left (Table 3). Of the 196 patients with pleural effusion after CABG surgery only, 144 (73.4%) had effusions that were unilateral or larger on the left whereas only 14 (7.2%) had effusions that were unilateral on the right or larger on the right. The distribution of the pleural effusions in patients who had both CABG and valve surgery did not differ significantly from that of the patients who had CABG surgery only ($\chi^2 = 4.31$, $p = 0.50$). However, the patients who underwent valve surgery only had significantly more effusions on the right ($\chi^2 = 6.42$, $p = 0.04$).

Most of the effusions were small and were predominantly left sided (Tables 3 and 4). However, 40 of the patients did have large (occupying $>$ 25% hemithorax) pleural effusions. The prevalence of large effusions was similar in the 245 patients who received both SVG and IMA grafts (10.6%), the 37 patients who received both CABG and valve surgery (13.5%), and the 40 patients who received only valve therapy (15.0%). Although the prevalence of large effusions (4.5%) tended to be less in the 67 patients who received SVG grafts only, there was no significant difference in the incidence of large effusion in the patients who received only SVG compared with those who received both a SVG and an IMA ($\chi^2 = 6.0$, $p = 0.20$).

Preoperative radiographs were available for 302 of the patients. Only 13 patients (4.3%) had a pleural effusion on the preoperative chest radiograph and in 10 the grading of the effusion was 1. Of the 27 patients who had large postoperative effusions and preoperative radiographs, only 2 (7.4%) had large effusions preoperatively.

Pleural fluid analysis was available for 15 of the patients who underwent thoracentesis (Table 5). The pleural fluid was an exudate in all patients except Patient 15. The pleural fluid obtained within the first 30 days of surgery tended to have a high red blood cell count. The pleural fluid differential cell count revealed predominantly lymphocytes or mesothelial-mononuclear cells in most patients. Four patients had pleural fluid eosinophilia, and each of these patients had pleural fluid red blood cell counts of about 20,000 mm^3.

We next attempted to determine what factors were associated with the development of a pleural effusion (Table 6). For this analysis, we combined the groups of patients who received only CABG and those that received CABG plus valve surgery. Patients were classified according to their largest effusion regardless of side. In general, there was no significant relationship between the occurrence of a pleural effusion and the age of the patient, the sex of the patient, whether or not they received antegrade or retrograde cardioplegia, operative time, or number of grafts received.

Three months postoperatively, we were able to contact 271 patients who had received a CABG by telephone. These included 29 with large effusions, 142 with small effusions, and 100 with no effusions. Of the patients contacted, 60 said that they had fluid in their chest after surgery. These 60 patients included 25 (86%) of those with large effusions, 26 (18.3%) with small effusions, and 9 (9.0%) with no effusion. Of the 29 patients with the large effusions by chest radiograph, 22 (75.9%) complained of dyspnea, 3 (10.3%) of chest pain, and 1 (3.4%) complained of fever. The prevalence of dyspnea (13.2%) in the other 242 patients was significantly less ($\chi^2 = 59.8$, $p < 0.001$).

TABLE 3. PREVALENCE OF PLEURAL EFFUSION ON CHEST RADIOGRAPH OBTAINED APPROXIMATELY 30 DAYS AFTER CARDIAC SURGERY

	CABG Only (*n = 312*)		CABG and Valve (*n = 37*)		Valve Only (*n = 40*)	
Effusion Size	Right Side	Left Side	Right Side	Left Side	Right Side	Left Side
0	239 (76.6%)	129 (41.3%)	24 (64.9%)	16 (43.2%)	28 (70.0%)	23 (57.5%)
1	60 (19.2%)	97 (31.1%)	11 (29.7%)	13 (35.1%)	6 (15.0%)	7 (17.5%)
2	8 (2.6%)	59 (18.9%)	0 (0%)	5 (13.5%)	4 (10.0%)	5 (12.5%)
3	5 (1.6%)	22 (7.1%)	2 (5.4%)	3 (8.1%)	2 (5.0%)	4 (10.0%)
4	0 (0%)	4 (1.3%)	0 (0%)	0 (0%)	0 (0%)	1 (2.5%)
5	0 (0%)	1 (0.3%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Definition of abbreviation: CABG = coronary artery bypass graft.

TABLE 4. PREVALENCE OF PLEURAL EFFUSIONS IN PATIENTS WHO RECEIVED IMA GRAFT COMPARED WITH THAT IN PATIENTS WHO RECEIVED ONLY SVG GRAFTS

	IMA ± SVG (*n = 282*)	SVG Only (*n = 67*)
Large effusion*	31 (10.9%)	3 (4.5%)
Small effusion†	152 (53.9%)	32 (47.8%)
No effusion‡	99 (35.1%)	32 (47.8%)

Definition of abbreviations: IMA = internal mammary artery; SVG = saphenous view graft.

* Largest effusion was ⩾ than Grade 3 (> 25% hemithorax).

† Largest effusion was ⩽ than Grade 2 (< 25% hemithorax).

‡ No effusion was present on either side.

$\chi^2 = 6.0$, $p = 0.2$. Patients who also received values are included in this analysis.

Thirty-five of the 271 patients (12.9%) reported receiving a thoracentesis within the first 90 days of surgery. Thoracentesis was performed in 23 of 29 patients (79.3%) with large effusions and in 12 of the remaining 242 patients (4.9%). One patient with a large effusion was treated with a chest tube. A second patient with a large effusion due to chylothorax was treated with a pleurectomy.

Six months postoperatively, we were able to contact 317 of the patients who had received CABG by telephone. In the interval period between 3 and 6 months, none of the patients had knowingly developed a pleural effusion who had not had a pleural effusion by 3 months. The pleural effusions had become much less symptomatic in the 3 to 6 month period after surgery. Of the 19 patients who had reported dyspnea at 3 months, only 5 remained dyspneic at 6 months. Moreover, only three patients had required an interval thoracentesis between 3 and 6 months after the CABG. Twelve months postoperatively we were able to contact 30 of the 34 patients with large effusion who had received a CABG. In the interval between 6 and 12 months after surgery, only two patients had received a thoracentesis, and no patient had received a more invasive treatment in the interval period. Overall, when these 30 patients were questioned regarding the treatment of their pleural effusion over the entire 12-month period, 8 (27%) said they received no invasive treatment for the pleural effusion, 16 (53%) said they received a single thoracentesis, 2 (7%) required two thoracenteses, and 4 (13%) required three or more thoracenteses. One patient was still receiving periodic thoracenteses 12 months after CABG. Twenty-two of the 25 patients who underwent thoracentesis reported that their dyspnea was alleviated with the thoracentesis.

DISCUSSION

The present study demonstrates that the prevalence of large pleural effusions 28 days after CABG surgery is approximately 10%. If one extrapolates this percentage to the 600,000 CABG surgeries that are performed annually in the U.S. (9), there would be 60,000 cases of large pleural effusion due to CABG surgery each year in the U.S. This would place CABG surgery as the fifth leading cause of pleural effusion after congestive heart failure, pneumonia, malignancy, and pulmonary embolism (10).

The prevalence of pleural effusions in the initial few days after CABG surgery has been reported to vary from 42 to 89% (1, 3, 4, 6). The prevalence depends somewhat on the method used to detect the pleural effusions as the highest rates are reported in those series that used ultrasound (6). Most of the after CABG effusions are small, are left sided, and regress spontaneously.

Previous studies on the prevalence of pleural effusion 1 month after CABG surgery are limited. The present study demonstrates that more than 50% of patients have a pleural effusion 1 month after surgery and that approximately 10% of patients have a pleural effusion that occupies more than 25% of the hemithorax at this time. Vargas and coworkers (6) assessed the prevalence of pleural effusion in 47 patients at 30 days after CABG surgery and reported that the prevalence of pleural effusion was 57.4%, which is comparable to the prevalence of 62.4% in the present study. Recently, Lancey and coworkers (11) reported that the prevalence of moderate or large pleural effusions 6 weeks after surgery was 11.4%, which is comparable to the prevalence that we found. In this latter series, 5.9% of the patients required a drainage procedure for their pleural effusion in the 6 weeks postoperatively (11).

Other researchers have studied the prevalence of pleural effusions at later time periods after CABG surgery. Hurlbut and associates (4) obtained chest radiographs 8 weeks postoperatively on 76 patients who had received IMA grafts and reported that 5 of 55 patients (9.1%) who received an IMA and underwent pleurotomy, and 3 of 21 patients (14.5%) who received an IMA without pleurotomy had a pleural effusion at the 8-week follow-

TABLE 5. PLEURAL FLUID VALUES ON PATIENTS UNDERGOING THORACENTESIS WITH PLEURAL FLUID ANALYSIS

Patient Number	Number of Days Postoperatively	RBC (*cells/mm³*)	WBC (*cells/mm³*)	Segs (%)	Lymphs (%)	Mesothelial-Mononuclear (%)	Eosinophils (%)	Protein (*gm/dl*)	LDH (%)
1	6	225,000	750	2	25	72	1	3.0	1,625
2	8							4.3	1,422
3	10	157,000	4,740	20	69	10	1	3.9	1,072
4	14	147,000	15,000	64	15	21	0	3.4	335
5	19	90,250	1,750	8	32	60	0	3.7	803
6	32	5,625	150	3	67	24	1	4.7	367
7	34	43,000	500	0	61	38	1	3.6	392
8	34	500	450	0	47	46	7	4.3	279
9	34	47,500	500	10	47	25	16	3.3	563
10L	34	21,125	3,625	0	68	5	27	4.6	989
10R	40	270	805	40	20	40	0	3.5	449
11	41	30,000	500	2	48	7	43	3.9	1,690
12	41	47,000	1,000	7	45	11	37	4.1	1,785
13	42	39,500	550	1	83	15	1	4.7	432
14	53	600	1,200	5	93	1	1	4.1	279
15	77	1,950	850	0	68	32	0	2.0	144

Definition of abbreviations: LDH = lactic acid dehydrogenase; RBC = red blood cell; WBC = white blood cell.

TABLE 6. RELATIONSHIP OF FACTORS TO THE PRESENCE OF A PLEURAL EFFUSION 30 DAYS POSTOPERATIVELY IN THE 349 PATIENTS WHO RECEIVED A CORONARY ARTERY BYPASS GRAFT

Operative Factor	No Effusion (*n = 131; 37.5%*)	Small Effusions (*n = 184; 57.7%*)	Large Effusions (*n = 34; 9.7%*)
Age of patient	61.2 ± 9.3	63.3 ± 11.7	64.3 ± 10.0
Number of females, n = 105	34 (32.3%)	58 (55.2%)	13 (12.4%)
Number of males, n = 244	97 (39.8%)	126 (51.6%)	21 (8.6%)
Number of grafts received	2.9 ± 1.1	3.2 ± 1.3	3.0 ± 1.0
Antegrade Cardioplegia, n = 164	64 (39.0%)	87 (53.0%)	13 (7.9%)
Retrograde Cardioplegia, n = 102	39 (38.2%)	56 (54.9%)	7 (6.9%)
Operative times, min			
Bypass	85 ± 48	96 ± 56	92 ± 50
Cross clamp	80 ± 43	87 ± 50	79 ± 36
Cut-to-close	238 ± 82.2	262 ± 154	243 ± 60
Total operating room time	299 ± 84	313 ± 84	306 ± 70

The figures did not differ significantly between the three groups for any of the operative factors.

up visit. Overall, 4 of these 76 patients underwent thoracentesis. Aarnio and coworkers (12) obtained chest radiographs 3 months postoperatively and reported that 21 of 91 (23%) patients receiving unilateral and 15 of 94 (16%) patients receiving bilateral IMA grafts had a pleural effusion. Only three of their patients underwent thoracentesis, and they do not say how large the effusions were. Landymore and Howell obtained chest radiographs 90 days after surgery and reported that 1 of 37 patients (3%) with SVG or valve surgery had a small pleural effusion, 5 of 34 patients (15%) with pleurotomy for IMA had a small pleural effusions, and none of 31 patients with IMA without pleurotomy had an effusion (13). The studies described previously in conjunction with the present study demonstrate that the prevalence of pleural effusion after CABG gradually decreases over the months after CABG.

Previous studies have suggested various factors that might be associated with a higher prevalence of pleural effusion after CABG surgery. In several studies, performance of an IMA graft in addition to a SVG graph has been associated with a higher incidence of pleural effusion (1, 4, 13). In the present study, the prevalence of large effusions was 10.9% in patients who received an IMA versus 4.5% in the patients who received only SVG. Although this difference did not reach statistical significance, the power of the test to detect a significant difference was only 0.27. When all the studies are taken together, it appears that use of an IMA is associated with a higher prevalence of pleural effusion.

Another factor that has been associated with a higher frequency of pleural effusion is topical hypothermia with iced slush. Nikas and coworkers studied 505 nonrandomized consecutive patients undergoing CABG surgery and reported that 60% of those who received topical hypothermia had a pleural effusion, whereas only 25% of those who did not receive topical hypothermia had a pleural effusion (14). Moreover, 25% of those in the hypothermia group required a thoracentesis, whereas only 8% of those in the control group required a thoracentesis (14). Allen and associates reported that the incidence of pleural effusion was 50% in 50 patients who received topical hypothermia but only 18% in 50 patients who did not receive topical hypothermia (15). In the present study, all the patients received topical hypothermia.

The present study suggests that the course of most large pleural effusions after CABG surgery is relatively benign. Although it has been reported that operative intervention such as thoracoscopy or thoracotomy has been necessary for some patients (7, 16, 17), most large pleural effusions occurring after CABG resolve within several months. In the present study, none of the 34 patients who had a large pleural effusion after CABG required either thoracoscopy or thoracotomy, and only one received a tube thoracostomy.

One possible criticism of the present study is that the studied sample might not be representative of the overall population of patients undergoing CABG surgery because postoperative radiographs were obtained in less than 25% of 1,600 patients undergoing cardiac surgery during the study period. Patients initially were contacted about the study when they were having their pre-operative respiratory evaluation. If the patients had emergency surgery they had no preoperative respiratory evaluation and were therefore not invited to participate in the study. This enrollment procedure would tend to select relatively healthy patients for the study and minimize the prevalence of pleural effusion. When the patients came back for their follow-up visit, the cardiac surgeon had to remember to request the chest radiograph, and they had to be willing to do this. It is unclear whether this selection factor would bias our results.

What is the etiology of the pleural effusions after CABG surgery? One possible explanation is congestive heart failure. We believe that this is unlikely because the prevalence of pleural effusions preoperatively was much lower than the prevalence 30 days postoperatively. Moreover, analysis of the pleural fluid demonstrated that the fluid was exudative in 14 of the 15 patients in whom it was analyzed (Table 5) in the present study. We believe that two factors contribute to the pathogenesis of the pleural effusions (7). First, trauma during surgery can lead to blood in the pleural space producing a bloody pleural effusion. As noted in Table 5, many of the pleural fluids were bloody. Second, the surgery can induce immunologic perturbations that can result in the development of the pleural effusion. The observation that many of the patients in the present study had predominantly small lymphocytes in their pleural fluid supports this contention. The development of the pleural effusion after CABG surgery might be a limited form of Dressler's syndrome (7), but it should be noted that patients with Dressler's syndrome classically present with chest pain and fever, both of which were uncommon in our patients.

In summary, approximately 10% of patients after CABG surgery will develop a pleural effusion that occupies more than 25% of the hemithorax. Most effusions that are due to the CABG surgery are left sided or are larger on the left side if the effusions are bilateral. The primary symptom of patients with pleural effusion after CABG surgery is dyspnea; chest pain and fever are distinctly uncommon. The long-term prognosis of patients

with pleural effusion after CABG is favorable. The effusions usually resolve with one or two thoracenteses, but occasionally several thoracenteses are required. The effusions resolve within 1 year of surgery in almost all patients.

***Acknowledgment*:** The authors would like to thank Dr. Barrett Conner for his careful review of the manuscript.

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