Computed tomography evaluation of different chest tube sites for residual pleural volumes after coronary artery bypass surgery

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Ann Saudi Med 2011; 31(4): 383-386

PMID: ****  DOI: 10.4103/0256-4947.83216

BACKGROUND AND OBJECTIVES: We investigated the efficacy of pleural drainage with the use of different chest tube methods in patients after coronary artery bypass graft (CABG) surgery.

DESIGN AND SETTING: Prospective randomized study of 60 patients undergoing elective on-pump single CABG surgery.

PATIENTS AND METHODS: The left internal mammary arterial grafts were harvested from all patients. The patients were separated into three groups: In one group (IC6, n=20), pleural tubes were inserted through the sixth intercostal space at the midaxillary line; in the second group (SX-r, n=20), rigid straight pleural tubes were inserted from the mediastinum through the subxiphoid area; and in the third group (SX-s, n=20), soft curved drainage tubes were inserted from the mediastinum through the subxiphoid area. The residual pleural effusion was examined by multislice CT scans within 8 hours of removal of the drainage tubes. Pain was evaluated according to standard methods.

RESULTS: The groups did not differ with respect to volume of residual pleural effusion (P>.05). The IC6 group had a higher mean pain score than the other two groups (P<.05), whose mean pain scores did not differ significantly from each other (P>.05). IC6 group patients had a higher requirement for analgesics. The rate of atelectasis was higher in group IC6 (P<.05).

CONCLUSION: CT scans revealed that different chest tube insertion sites have the same efficiency for draining of pleural effusion, although drainage tubes inserted through the thoracic cage may result in more severe pain.
PATIENTS AND METHODS
After approval was obtained from the local ethics committee and informed consent obtained from each patient, 60 patients who subsequently underwent elective single CABG procedures were enrolled into this study. Left internal mammary artery (LIMA) grafts were used in all patients. Re-do and emergency cases were excluded, as were any patients who had coagulation dysfunction.

Standardized techniques were used for anesthesia and cardiopulmonary bypass (CPB). Anesthetic premedication included midazolam (0.05 mg/kg) and scopolamine (0.5 mg) administered intramuscularly. Anesthesia induction was to be used with propofol (1.5 mg/kg), fentanyl (15 µg/kg) and pancuronium (0.1 mg/kg) and maintained with propofol (1 mg/kg/h), fentanyl (7 µg/kg/h) and sevoflurane. Drainage tube insertion sites were selected by surgeon preference. Patients were separated into three groups according to their drainage tube insertion sites and tube types: In one group (IC6, n=20), rigid pleural drainage tubes were inserted through the sixth intercostal space at the midaxillary line; in the second group (SX-r, n=20), rigid pleural drainage tubes were inserted through the subxiphoid route. In the third group (SX-s, n=20), soft curved pleural drainage tubes were inserted through the subxiphoid area. The drainage tubes were placed into the costovertebral sinus in the SX-r and SX-s groups. In all patients, 36 F drainage tubes without heparin coating and an underwater seal were used, and the tubes were placed on continuous suction (5-10 cm H₂O). The total and daily drainage volumes, blood transfusion volumes, pleural effusion volumes, pain scores and timing of drain removal were recorded and compared between the three groups.

Drainage tubes were removed when the drainage output declined to <25 mL/h and the macroscopic appearance of the drainage fluid had changed from heavily blood-stained to serosanguinous. A thoracic CT scan was performed within 8 hours of the removal of drainage tubes. All CT scans were evaluated by the same radiologist, and the residual pleural effusion volumes were measured for each patient. Spiral CT scans were performed as 5-mm-long, 3-mm-wide cross sections with a single breath hold by a Sensatrin-16 scanner (Siemens, Germany). Axial, sagittal and coronal planes were examined on a Siemens Navigator. The volume of the residual pleural effusion and atelectasis were measured automatically with a freehand volume programmer.

The sensation and severity of pain were assessed according to standard techniques in each patient during the postoperative period and during the removal of drains. The pain quality and intensity were assessed routinely by self-reporting using a visual analog scale (VAS). They were quantified with a modified standard score (0=no pain to 10=unbearable pain).⁶ Local anesthetics were not used intercostally, and epidurals were not used.

Continuous variables were reported as means and standard deviation (SD) in the tables and text. Categorical variables were compared using the χ² test and reported as percentages. The distribution of continuous variables was checked using the one-way ANOVA and post hoc Tukey test. All P values less than .05 were considered to be statistically significant.

RESULTS
Demographic characteristics, concomitant diseases and baseline clinical and laboratory data were similar among the three groups (Table 1). The cross-clamp durations, cardiopulmonary bypass durations, number of grafts per case, and conduit types are shown in Table 2. There were no statistically significant group differences with regard to intraoperative parameters.

The mean pain score was higher in the IC6 group than in the SX-r and SX-s groups in the postoperative period and during removal of the drain (P<.05 for all comparisons). Analgesic demand was also higher in the IC6 group than in the other groups. The prevalence of atelectasis was found to be lower in the SX-r and SX-s groups than in the IC6 group. There were no group differences in the volume of residual pleural effusions (P>.05; Table 3).

DISCUSSION
Mediastinal and pleural effusions or hematomas occur in the mediastinum or pleural spaces in the early postoperative period after CABG surgery. The incidence of pleural effusion is higher in patients who receive LIMA grafts than in those who receive saphenous grafts.⁵,⁹ Pleural effusions may occur due to insufficiency of lymphatic drainage, inflammation of the pericardium, post-pericardiotomy syndrome¹ and harvesting of the LIMA via a pleurotomy.¹³ To evacuate the effusion, a pleural drain must be inserted through the mediastinum or directly through the intercostal muscles.

Post-CABG pleural effusions have been examined by different diagnostic tools, such as daily CXRs, thoracic USG and ECHO.⁴,⁸ USG and ECHO could lead to
false-negative results on the existence of pleural effusion, and there are certain intrinsic difficulties involved with the use of these imaging modalities for the measurement of pleural effusion volume. Effusions that are located in the mediastinal or paravertebral parts of the thoracic cavity are particularly sensitive to such difficulties. Effusions in the upper chest cavity can also at times be very difficult to measure when the patient is in the supine position. In USG and ECHO examinations, there are also limitations in finding the effusion in specific anatomical sites due to non-solid, air-contained organs sitting anterior to the effusion. CT examinations could eliminate these limitations by identifying otherwise hidden collections and give more accurate assessments of the volumes of residual pleural effusion. Additionally, the duration of CT scanning is shorter than that of the other imaging modalities. In our study, CT scans were performed within 8 hours of the drain removal to prevent misjudgment of the cause of pleural effusion. There were no statistically significant relationships between drain insertion site and residual pleural effusion volume. Thoracentesis was not required in any patient after drain removal (Table 3).

There is not yet a clear consensus as to how the various drain insertion sites compare to one another with respect to efficacy or patient comfort during the postoperative period. Previous studies have mostly analyzed the relationship between the site of drains and pulmonary function by using CXR imaging. Patients who undergo a median sternotomy may have moderate postoperative pain due to the surgery, and additional intercostal and periosteal nerve irritation may occur as a result of respiratory movements. Drains that were inserted through the intercostal muscles caused more pain than the subxiphoid drains, and respiratory physiotherapy was more difficult to carry out in these patients during the early postoperative period. In the current study, our findings regarding the relationship between pain and chest tube insertion site were similar to those found in the literature. We noted a significant association between increased pain and insertion site (P<.01, Table 3).

Although pain is not the only parameter that adversely affects pulmonary function and the cough reflex, its importance in patient comfort and its association with increased risk of atelectasis make it an important consideration. In our study, postoperative atelectasis was observed in a total of 6 patients (10%), including 5 (8%) in the IC6 group and 1 (2%) in the SX-r group (Table 3). Airway clearing was performed by bronchoscopy in these patients because of excessive pulmonary secretions. It is noteworthy that the 5 patients in the IC6 group who developed postoperative atelectasis had no preoperative respiratory diseases; it can be deduced that their increased pain levels due to the intercostal pleural drain were directly responsible for their atelectasis prior to the removal of the drain. The IC6 group patients had a higher demand for analgesia. Analgesics can have secondary effects, such as vomiting, lack of secretion, sedation, urinary retention and cardiac and respiratory depression.

We used rigid straight or soft curved drains to insert through the subxiphoid region. Contrary to the straight

Table 1. Preoperative characteristics of patients.

| Parameters | Group 1 (n=20) | Group 2 (n=20) | Group 3 (n=20) | P  |
|------------|---------------|---------------|---------------|----|
| Mean age (SD) | 57.3 (11) | 59.3 (6.3) | 58.9 (11.1) | .876 |
| Gender, n(%) | 10 (50) | 8 (40) | 4 (20) | .199 |
| Diabetes mellitus, n (%) | 14 (70) | 8 (40) | 12 (60) | .273 |
| Hypertension, n (%) | 14 (70) | 16 (80) | 16 (80) | .596 |
| COPD, n (%) | 6 (30) | 2 (10) | 4 (20) | .498 |
| Mean body mass index (SD) | 25.5 (4.5) | 26.8 (3.3) | 27.3 (2.5) | .558 |
| Ejection fraction <50%, n (%) | 7 (35) | 10 (50) | 11 (55) | .411 |
| Mean platelet count x10^3 (SD) | 251 (92) | 300 (86) | 250 (70) | .398 |

COPD: chronic obstructive pulmonary disease

Table 2. Intraoperative data of patients.

| Parameters | Group 1 | Group 2 | Group 3 | P  |
|------------|--------|--------|--------|----|
| Mean grafts per patient (SD) | 2.4 (1.1) | 2.5 (0.5) | 2.8 (1.1) | .662 |
| Graft types | Internal mammary artery | 20 | 20 | 20 |
| Radial artery | 2 | 1 | 1 |
| Saphenous vein | 25 | 29 | 34 |
| Mean CPB time (SD) | 70.3 (10.5) | 84.6 (21.5) | 84.4 (30.7) | .422 |
| Mean cross clamp time (SD) | 47.8 (7.8) | 51.1 (10.6) | 50.7 (20.7) | .885 |
| Mean duration of operation (h) (SD) | 3.5 (0.2) | 3.7 (0.3) | 3.6 (0.2) | .753 |

CPB: cardiopulmonary bypass
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Table 3. Postoperative data of patients.

|                      | Group 1 (n=20) | Group 2 (n=20) | Group 3 (n=20) | P     |
|----------------------|----------------|----------------|----------------|-------|
| 24-h drainage (cc)   | 942.8 (276.3)  | 825 (233)      | 977.8 (215.2)  | NS    |
| Total drainage (cc)  | 1000 (281.6)   | 998.8 (254.9)  | 1111 (282.6)   | NS    |
| Platelet count x10^3 | 171 (64.6)     | 176 (72.9)     | 174 (53.5)     | NS    |
| Blood transfusion    | 4.37 (1.5)     | 3 (1.1)        | 3.66 (1)       | NS    |
| Pain score           | 2.6 (1.2)      | 1.2 (0.8)      | 1.3 (0.8)      | 0.01  |
| Time of drain removal (h) | 28.3 (8.7)    | 25.1 (6.5)     | 31 (8.2)       | NS    |
| Residual thoracic volume (cc) | 47.6 (37.9) | 49.8 (29.3) | 53.5 (14.8) | NS    |
| Atelectasia prevalence, n (%) | 5 (25)       | 1 (5)          | -              | 0.05  |

Values are mean (standard deviation), unless otherwise noted. NS: not significant.

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