

The use of flexible spiral drains after non-cardiac thoracic surgery. A clinical study

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Abstract

Objective: After an observational study on 50 patients determined the efficacy and safety of a small calibre (19 F), flexible, fluted spiral drains with round cross-section after non-cardiac thoracic surgery we undertook a prospective study to compare these drains to standard chest drains also in terms of pain using a Visual Analog Score. **Methods:** One hundred consecutive patients who had to undergo non-cardiac chest surgery either by thoracotomy or by VATS were randomly assigned to receive small calibre drains with round cross-section (group A) or the standard chest drains (group B) to drain the pleural space. Drains were connected to a unitized chest drainage system. Pain was assessed using a Visual Analog Scale (VAS) 0-100. **Results:** The amount of fluid evacuated daily in patients who received the spiral drains was as much as 1150 ml, that of patients who received standard drains was as much as 950 ml. In no case did spiral drains have to be replaced with standard tubes. In group A first drain was removed after a mean of 3.4 days and the second after a mean of 5.9 days; in group B after a mean of 4.1 and 6.1 days, respectively. Patients were discharged after a mean of 8.5 days in group A (SD 4.04) and 8.1 days in group B (SD 4.76). There were no drains-related complications in both groups. The drains-related pain for the patient was significantly less for patients with spiral drains compared to standard drains at rest, during cough induced by respiratory therapists and at the time of removal. **Conclusions:** Spiral drains proved to be at least as safe and effective as conventional tubes after lung surgery; they allowed for evacuation of large amounts of blood/fluid as well as air, and were associated with minimal discomfort.

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1. Introduction

After the first report of the use of chest tubes for postoperative thoracic patients by Lilienthal in 1922 [1], the drainage of the pleural space has become standard after lung surgery, and is usually carried out using one or two large bore (28-36 F) semi-rigid plastic tubes. The aims are the monitoring of bleeding, the removal of blood, fluid and air, and to allow the full expansion of the residual lung and to re-establish correct ventilatory mechanics by restoration of negative intrapleural pressure, the assessment of air leaks and lung healing or, in the case of pneumonectomy, the maintenance of the mediastinum in axis.

However, large bore chest drainages can impinge on the lung and, passing through the intercostal spaces, create great discomfort for the patient who often experiences pain;

as a result there may be restriction of deep breathing, sputum retention and atelectasis.

Although less invasive surgery (VATS) is claimed to be less painful, the use of chest tubes greatly reduce the benefits of a less invasive procedure. We employed a small (19 F), flexible, fluted spiral drain following a wide range of lung resections (from wedge resection to pneumonectomy) performed either by thoracotomy or by VATS at first in 50 patients to evaluate their safety and efficacy and then we undertook a prospective study on 100 patients to compare these new drains to standard drains.

We report on the first fifty cases (observational) in which these new drains were used and on the prospective study undertaken.

2. Materials and methods

From March 2003 newly designed flexible, fluted spiral drains with round cross-section (Spiral Drain, Redax s.r.l. Mirandola, Modena, Italy) of a relatively small calibre (19 F) were used by a few of the surgeons in our thoracic surgery

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Fig. 1. Schematic drawing of a spiral drain showing its cross-section.

unit, after informed consent, as an alternative to standard chest tubes (28-36 F) after non-cardiac thoracic surgery procedures. The new drain is made of silicone, radiopaque and flexible, and has a spiral shape with four longitudinal grooves (Figs. 1 and 2), the spiral part is injection-moulded and welded to a silastic round, transparent 19 Ch tube.

The draining surface of such a configuration is 12 cm² compared to 4 cm² of the holes of a standard chest tube; these drains can support negative pressure much higher than the commonly used one of 20 cmH₂O without collapsing.

This new drain was used to drain the chest after lung or pleural surgery performed either by thoracotomy or by VATS except in case of talc pleurodesis. Two drains were left in place after all procedures, except after pneumonectomy in which a single drain was left. To keep the anterior drain in the correct position we created one or two 'loops' in the pleura under which the drain was passed. The posterior drain was placed free in the costo-phrenic gutter in the case of lower lobectomy, or in the case of upper lobectomy directed upward, and kept in position by another pleura 'loop'. Drains were connected to a disposable unitized chest drainage system (a balanced system after pneumonectomy) and put under aspiration (usually -20 cmH₂O), except in the case of pneumonectomy.

The drains and the chest drainage unit were checked twice a day for tidaling, bubbling, or fluid level in the waterseal chamber by a surgeon, and checked again by nurses during their rounds; the daily outputs were recorded. Drains were removed according to the following rules: after standard pneumonectomy, the day after the operation, after completion pneumonectomy (CP) or extrapleural pneumonectomy after 48/72 h; after lobectomy, wedge resection or VATS procedures, whenever no bubbling occurred with



Fig. 2. Spiral drains. The total length of the drain is 110 cm (30 cm the white spiral part). The arrangement of the drains in this picture simulate the intrathoracic arrangement after an upper lobectomy.

cough and tidaling was minimal or absent and the amount of fluid was less than 200 ml/day.

In-hospital chest X-rays were taken a few hours after the operation, on the first and second postoperative (PO) days routinely, and subsequently when required and always after removing the drains, before discharging the patient.

Blood gas analysis was obtained after operation and the first and second PO day, then when clinically needed; pulse oxymetry was used to monitor the blood oxygen saturation during the two PO days and then during respiratory physiotherapy.

After the first 50 cases (observational phase) a prospective study was undertaken to compare these new drains to standard drains; 100 patients were enrolled and randomly assigned to receive spiral drains (group A) or standard drains (group B).

The same criteria as above were used to check patients and to check and remove drains, moreover pain related to drains was assessed using a Visual Analog Scale (VAS) of 0-100 during the first 2 postoperative days either at rest or during cough induced by respiratory therapists and at the time of removal. Postoperatively pain control was obtained with a continuous infusion of Tramadol and Ketorolac for the first 2 days and then upon request by the patient. No intravenous analgesia was offered to the patients before drain removal, only local subfascial lidocaine was given to patients.

Statistical analysis was performed with the Student's *t*-test for two independent groups of data.

Significance was placed at 0.05.

3. Results

3.1. Observational study

Fifty patients were drained with spiral drains after pleural/lung surgery after informed consent. Operations performed were: pneumonectomy 5 (1CP), lobectomy/bilobectomy 20, wedge resection 6, decortication 4, pleurectomy/decortication 1, exploratory thoracotomy 1, bilateral resection via sternotomy 1, VATS procedures 12 (6 pneumothorax, 6 wedge resections). The amount of blood/fluid removed was as much as 950 ml/day; drains were removed after a variable period ranging from 1 to 15 days. A full expansion of the residual lung was readily obtained in all cases and it was sustained throughout the postoperative period, and in pneumonectomy patients the mediastinum was kept in axis with an empty pleural space. We observed one apical hemothorax after a right upper lobectomy due to malfunction of the drains related to poor check of the drains that were left bent during the night; the clot was removed by video thoracoscopy the day after operation and a new spiral drain was placed with complete recovery; the removed drain was inspected and no clot was found to obstruct the grooves. After removal the drains were carefully inspected, and in no case were blood clots found in the drain grooves. In no case did spiral drains have to be replaced with standard tubes. A small apical pleural spaces was present at the time of discharge in few cases without any clinical importance. Patient discomfort was minimal and many patients did not complain at all about

their chest drains. A purse string suture was tied at the time of drain removal but in cases of early removal of the drains (2nd-4th PO day) the edges of the skin were joined together by wound closure strips without any problems. Patients were discharged after a median of 7 days (range 3-24 days) without drains.

3.2. Prospective study

One hundred patients were enrolled and randomly assigned to receive spiral drains (group A) or standard drains (group B). In group A were performed 21 lobectomies, 7 pneumonectomies, 9 wedge resections (in a few cases multiple wedge resections), 8 VATS procedures (pneumothorax or wedge resections) 2 decortications, 1 exploratory thoracotomy, 1 removal of giant fibrous tumor of the pleura, 1 ligature of thoracic duct for a posttraumatic chylothorax; in group B were performed 19 lobectomies, 2 segmental resections, 7 pneumonectomies, 9 wedge resections (a few multiple), 8 VATS procedures, 1 decortication, 2 exploratory thoracotomies, 2 mediastinal tumors removal.

The maximal amount of blood removed daily by spiral drains was as much as 1150 ml (a case of extrapleural pneumonectomy) and the maximal amount of blood removed daily by standard drains was 950 ml.

Except for patients who underwent standard pneumonectomy who had their drain removed the first PO day, patients in group A had their first drain removed after a median of 3 days (range 1-7 days) and the second drain after a median of 5 days (range 2-20) while patients in group B had their first drain removed after a median of 4 days (range 1-10) and the second after a median of 6 days (range 3-12). A purse string suture was tied at the time of drain removal in all group B patients but in group A in cases of early removal of the drains (2nd-4th PO day) the edges of the skin were joined together by wound closure strips without any problems.

Patients in group A were discharged after a mean of 8.5 days (range 3-25 days) and in group B after a mean of 8.1 days (range 2-27 days) ($P=NS$). The longest hospital stay was 25 days in group A and 35 days in group B, however, the length of stay was not related to the type of drains used but to medical complications.

There were no drains-related complications in both groups; one patient in group A had to be drained after removal of a spiral drain due to a large pneumothorax detected at chest X-ray before discharge.

Mean VAS for pain in the first postoperative day at rest was 21.3 (SD 16.9) in group A and 32.7 (SD 19.4) in group B ($P=0.002$); in the second postoperative day it was 13.8 (SD 15.9) and 21.3 (SD 20.5), respectively ($P=0.05$). Mean VAS for pain in the first PO day during cough induced by respiratory therapist was 50.3 (SD 21.1) in group A and 63.6 (SD 21.5) in group B ($P=0.002$); in the second PO day it was 36.2 (SD 20.4) and 54.3 (SD 21.9), respectively ($P<0.001$). VAS score for drain removal was 48.1 (SD 6.14) in group A and 59.3 (SD 9.74) in group B ($P<0.001$) (mean value for the two drains was used in patients with two drains).



Fig. 3. Chest X-ray after right upper lobectomy.

4. Discussion

The use of small, flexible, fluted drains has been reported after cardiac surgery to drain the pericardial space and the pleural space [2,3], but the use of similar drains after lung surgery has never been reported. Standard chest tubes are routinely used after lung surgery and are usually associated with a low complication rate. However, due to their rigidity intrapleural tubes may favor the perpetuation of air leaks physically by preventing apposition of the lung with the pleural surfaces, or by trapping the lung within the chest drain openings due to suction [4]. Thrombus formation within the drain can make the drain useless and promote accumulation of fluid in the pleural space moreover clearance techniques like stripping can damage the lung generating vacuums of up to -400 cmH₂O and are no longer

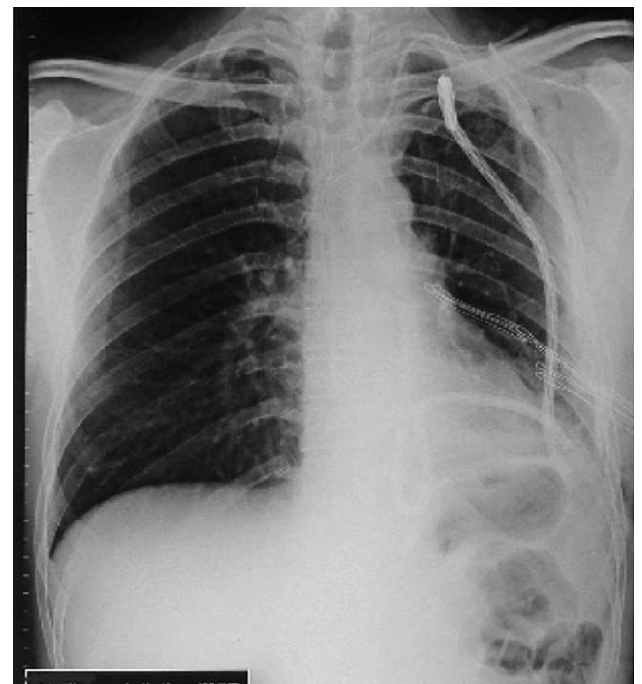


Fig. 4. Chest X-ray after left lower lobectomy.

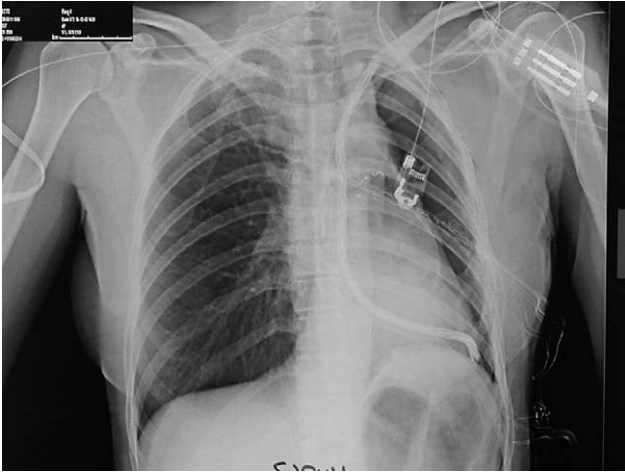


Fig. 5. Chest X-ray left pneumonectomy.

considered indicated for the maintenance of chest tube patency as well as milking [5,6]. If improperly positioned, rigid L shaped tubes can impinge on the pericardium, with possible negative consequences for heart function. Recently Horner's syndrome related to direct pressure of the tip of the chest tube on sympathetic chain has been reported [7]. Because of their size and rigidity standard chest tubes may limit ambulation and deep breathing, eliciting pain. Spiral drains exert a constant suction over the entire length of the fluted portion of the drain, and their draining surface is calculated as 12 cm² compared to 4 cm² of standard tubes. These drains function by capillary action, so blood and fluids flow into the four spiral grooves, and the spiral part of the drain is connected to a drain tube with a smooth transition between spiral drain and drain tube. The drain tube can also be easily connected with a single or Y connector to a unitized chest drainage system put under aspiration, so that the drains work by capillarity plus aspiration. In our experience these drains proved adequate even in patients with excessive bleeding; they were able to remove as much as 1150 ml of blood daily. Although some concern may be raised as to the efficacy of these drains in removing air from chest cavities, this was not a problem in our experience; the drains were able to evacuate air from the pleural space in all patients who underwent a lung resection less than a pneumonectomy, and in the case of pneumonectomy the drain connected to a balanced system was able to evacuate blood and to allow free entrance and exit of air into and from the pleural space and keep the mediastinum in axis (Figs. 3-5). The spiral design allows for

a total lack of kinking when the drain is positioned in curved placements, subject to traction or unusual positioning (patient movements/internal organ movements); this total lack of kinking and collapsing may explain the lack of occlusion of the drains. In our study/patients no drain was found obstructed by clots and no patient required supplemental drainage with standard chest tubes.

Patients experienced less pain with spiral drains than with standard tubes, mean VAS score was significantly lower in group A compared with group B. Although it is difficult to separate the pain due to thoracotomy from pain related to drains the difference was easily appreciated after VATS surgery in which drains exit from holes performed to perform the video-thoracoscopic procedure. Moreover the skin incisions to place spiral drains are smaller those that used for conventional drains, are less disfiguring and can be closed with wound closure strips. The cost of a spiral drain is 50% higher than that of a standard Silastic tube (15 versus 10 Euros) but a wider use could contribute to a reduction of its cost.

In conclusion, spiral drains have been found to be at least as safe as large-bore semi-rigid tubes, and as effective in monitoring bleeding, in removal of blood/fluid and air from the pleural space and in allowing full expansion of residual lung or, in the case of pneumonectomy, in maintaining the mediastinum in axis. Patients experience less pain with spiral drains than with standard drains. These conclusions followed and confirmed the impression of the observational study on 50 patients.

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