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Original article

Effectiveness of Small-bore Ambulatory Pleural Drain in Treatment of Pneumothorax and Haemothorax

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Abstract

Background: Pleural drainage is a life-saving procedure that is commonly performed to evacuate pleural collection of air or liquid from traumatic or non-traumatic causes. The pleural tube drain is commonly connected to underwater seal bottle thereby limiting the movement of the patients with attendant risks of immobilisation. There are reports of pleural drainages utilising small bore pleural drains attached to drainage bag and asserted to be as effective as large bore thoracic catheter connected to underwater seal bottle. In addition to the reported effectiveness of small bore ambulatory pleural drainage, the risks of prolonged immobilisation are mitigated, and there is saving of costs. Literature search has not revealed any comparison of the two pleural drainage systems in Nigeria, hence this index study. ***Objective:*** To compare the pleural drainage characteristics of small bore pleural drains attached to drainage bag with those of large bore thoracic catheters connected to underwater seal bottle in the management pneumothorax and haemothorax. ***Results:*** Among patients with pneumothorax, 66.7% of conventional group and 100% of small bore group regained normal respiratory rate before removal o pleural drain, although at 30 days post drainage check all n the two groups were normal. Using oxygen saturation (SpO_2), conventional drainage system was initially better (66.7% vs 25% $p<0.0001$), later inferior (83.3% vs 100%), and finally same at follow-up (100% vs 100%). Lung re-expansion was also initially better in the conventional drainage group at 30 minutes following commencement of pleural drainage than in the small bore pleural drain group (66.7% vs 50.0%), but afterward became complete in all patients in the two groups before removal of pleural drain and at 30 days follow up. Duration of pleural drainage and length of hospitalisation were shorter in more patients in the small bore group than in the large bore group ($p=0.571$). In the patients with haemothorax, there was no statistically significant difference in any outcome measure among the groups. ***Conclusion:*** The use of small bore pleural drains was as equally effective as the use of large bore chest tubes in the management of pneumothorax and haemothorax.

Keywords: ***Treatment of pneumothorax and haemothorax, Small-bore ambulatory pleural drain***

Introduction

Small bore pleural drains with external diameter less than 20 French gauge have been increasingly used in adult cardiothoracic surgical practice all over the world.[1] This implies that less of large bore chest tubes with external diameter greater than 20 French gauge is used in adult cardiothoracic surgery.[1] When small bore pleural drain is connected to drainage bag across a one-way valve, it can be used in ambulatory form and in suitable patients as outpatients. The advantages of small bore pleural drains are said to include ease of insertion, less pain during insertion and while tube is in place, patient's comfort, mobility, cost saving, shorter duration of hospital stay, and sometimes avoidance of hospitalisation.[2-4] Some disadvantages reported against small bore drain are higher complications like tube blockade.

Two studies within Nigeria related to small bore pleural drain did not compare outcomes with the conventional chest tube connected to underwater seal bottle.[5,6] Therefore the present study aims to evaluate the effectiveness of small bore pleural drain in comparison with the conventional chest tube connected to underwater seal bottle in the management of pneumothorax and haemothorax in Nigerian patients.

Material and methods

A prospective study comparing the effectiveness of small-bore ambulatory pleural drain and conventional chest drainage system in treatment of haemothorax and pneumothorax. Ethical approval was obtained from the institutional health research ethics board.

Patients were grouped into the two arms for the study:

Group 1: Patients diagnosed to have haemothorax or pneumothorax underwent treatment with conventional chest drainage system using size 28 French gauge chest tube connected to underwater seal bottle.

Group 2: Patients diagnosed to have haemothorax or pneumothorax underwent treatment with the tubing of urobag attached to its drainage bag. This qualifies for small-bore pleural drain because the external diameter is equivalent to 15 French gauge.

Inclusion criteria included all consented adult patients diagnosed to have haemothorax or pneumothorax necessitating drainage, while the exclusion criteria included non-consent, empyema thoracis and paediatric patients.

Outcomes of measures included respiratory rate and peripheral arterial oxygen saturation (SpO_2) at 30 minutes before treatment, 30 minutes after commencement of treatment, 30 minutes before removal of chest drain and at 30 days after discharge. Lung re-expansion was assessed with post procedure chest radiographs done 30 minutes after commencement of treatment, 30 minutes before removal of chest drain and at 30 days after discharge. Also duration of the pleural drainage, length of hospital stay, and any observed complications were analysed and compared amongst the two arms of the study. Complications of interest were those related to the drainage system and included tube blockage due to blood/fibrin clots, tube collapse, dislodgement/displacement of the tube from pleural cavity and disconnection of tube from the drainage bottle.

Analysis of data was undertaken using STATA software. Students t-test for continuous data and the chi-squared test (2 × 2 table) for categorical data.

Results

Table 1 shows the changes noted among the patients with pneumothorax. Respiratory rate was abnormal in all patients in the two arms of the study before and at 30 minutes into the commencement of pleural drainage. At 30 minutes before removal of the chest drain 100% in the small-bore group and 66.7% of the conventional drainage group achieved normal respiratory rate. The difference was not statistically significant [p=0.058]. However at 30 days follow up, all patients in the two groups of the study had achieved and maintained normal respiratory rate. It is also shown that SpO_2 was abnormal in all patients of the two groups 30 minutes before chest drainage. At 30 minutes following commencement of treatment, 66.7% and 25.0% of patients in conventional drainage group and small-bore group respectively achieved normal SpO_2. The difference was statistically significant [p<0.0001]. At 30 minutes before removal and 30 days after removal of pleural drain, the SpO_2 was normal in 100% of the patients in the small bore drain group while in the conventional drainage system, it was normal in 83.3% at 30 minutes before removal and in 100% at 30 days follow-up. The difference was not statistically significant p=0.384

No patient in the two groups had full lung expansion before pleural drainage. However at 30 minutes after pleural drainage, 66.7% of patients in the conventional drainage system group and 50.0% of patients in the small bore pleural drain group achieved complete lung re-expansion. The difference was not statistically significant (p=0.384). The lungs were fully re-expanded in all patients in the two drainage groups at 30 minutes before removal of chest tubes and at 30 days follow-up. Duration of drainage was less than five days in 50.0% and greater than five days in the remaining 50.0% of patients on conventional drainage system while it was less than five days in 75.0% and more than five days in the remaining 25.0% of patients using small bore pleural drain. Length of hospitalisation was less than seven days in 50.0% and more than seven days in the remaining 50.0% of patients on conventional drainage system while it was less than seven days in 75.0% and more than seven days in the remaining 25.0% of patients using small bore pleural drain.

Table 1: Comparison of proportion of respondents with pneumothorax who recovered after CVT and Urobag interventions

Characteristics	CVT	Urobag	Total	P value
Respiratory rate				
30 mins before chest tube drainage Normal	0 (0.0)	0 (0.0)	0 (0.0)	0.058
30 minutes after chest tube Normal	0 (0.0)	0 (0.0)	0 (0.0)	
30 minutes Before removal of chest tube Normal	4 (66.7)	4 (100.0)	8 (80.0)	
30 days after removal Normal	6 (100.0)	4 (100.0)	10 (100.0)	
SpO_2				
30 minutes before chest tube drainage Normal	0 (0.0)	0 (0.0)	0 (0.0)	<0.0001*
30 minutes after chest tube drainage Normal	4 (66.7)	1 (25.0)	5 (50.0)	
30 minutes before removal Normal	5 (83.3)	4 (100.0)	9 (90.0)	
30 days after removal Normal	6 (100.0)	4 (100.0)	10 (100.0)	

Lung expansion 30 minutes before chest tube drainage Normal	0 (0.0)	0 (0.0)	0 (0.0)	0.384
30 minutes after chest tube drainage Normal	4 (66.7)	2 (50.0)	6 (60.0)	
30 minutes before removal Normal	6 (100.0)	4 (100.0)	10 (100.0)	
30 days after removal Normal	6 (100.0)	4 (100.0)	10 (100.0)	
Duration of drainage Less than 5 days More than 5 day	3 (50.0) 3 (50.0)	3 (75.0) 1 (25.0)	6 (60.0) 4 (40.0)	0.571
Length of Hospital stay Less than 7 days More than 7 days	3 (50.0) 3 (50.0)	3 (75.0) 1 (25.0)	6 (60.0) 4 (40.0)	0.571

Table 2 depicts the observations of the drainage characteristics of the ten patients with haemothorax undergoing pleural drainage using the two drainage systems. Before pleural drainage respiratory rate was abnormal in all patients of the two groups. This result was unchanged at 30 minute into the commencement of pleural drainage. However at 30 minutes before removal of chest tube 100% of patients in the conventional drainage group had normal respiratory rate, while normal respiratory rate was in 75.0% of the small bore group. The difference was not statistically significant (p=0.167). Finally at 30 days follow-up assessment, all patients in the two arms of drainage had normal respiratory rate. For SpO_2 no patient in the two groups had normal SpO_2 before pleural drainage. At 30 minutes into pleural drainage, only 16.7% and 25.0% respectively of conventional drainage and small bore pleural drain group had normal SpO_2. At 30 minutes before removal of pleural drain, 100% of patients in the conventional drainage system had normal SpO_2, while 75.0% of patients in the small bore group had normal SpO_2. The difference was not statistically significant (p=0.11). By the 30 days follow-up assessment, all patients of the two treatment arms had achieved normal SpO_2.

The pre-treatment chest radiograph showed that all patients in the two arms of the study had partially collapsed lung on the haemothorax side. Checked chest radiograph done 30 minutes after evacuation of the accumulated haemothorax showed complete lung expansion in 83.3% of patients in the conventional drainage group and 100% of the small bore group. The difference was not statistically significant (p=0.581). Subsequent re-assessments at 30 minutes before removal of chest tube and at 30 days follow-up showed complete lung re-expansion in all patients in the two arms of the study.

Duration of drainage was less than 5 days in 66.7% of the conventional drainage system and in 50.0% of the small bore group whereas in 33.3% of the conventional drainage group and 50.0% of the small bore group, the drainage was for more than 5 days. The length of hospitalisation was evenly distributed among the two treatment groups. 50.0% in each arm spent less than one week while the remaining 50.0% spent more than one week on admission.

Table 2: Comparison of proportion of respondents with heamothorax who recovered after CVT and Urobag interventions

Characteristics	CVT (n=6)	Urobag (n=4)	Total (n=10	P value
Respiratory rate 30 mins before chest tube drainage Normal	0 (0.0)	0 (0.0)	0 (0.0)	0.167
30 minutes after chest tube Normal	0 (0.0)	0 (0.0)	0 (0.0)	
30 minutes Before removal of chest tube Normal	6 (100.0)	3 (75.0)	9 (90.0)	
30 days after removal Normal	6 (100.0)	4 (100.0)	10 (100.0)	
SpO_2 30 minutes before chest tube drainage Normal	0 (0.0)	0 (0.0)	0 (0.0)	0.11
30 minutes after chest tube drainage Normal	1 (16.7)	1 (25.0)	2 (20.0)	
30 minutes before removal Normal	6 (100.0)	3 (75.0)	9 (90.0)	
30 days after removal Normal	6 (100.0)	4 (100.0)	10 (100.0)	
Lung expansion 30 minutes before chest tube drainage Normal	0 (0.0)	0 (0.0)	0 (0.0)	0.581
30 minutes after chest tube drainage	5 (83.3)	4 (100.0)	9 (90.0)	

Normal 30 minutes before removal Normal 30 days after removal Normal	6 (100.0) 6 (100.0)	4 (100.0) 4 (100.0)	10 (100.0) 10 (100.0)	
Duration of drainage Less than 5 days More than 5 days	 4 (66.7) 2 (33.3)	 2 (50.0) 2 (50.0)	 6 (60.0) 4 (40.0)	 0.598
Length of Hospital stay Less than 7 days More than 7 days	 3 (50.0) 3 (50.0)	 2 (50.0) 2 (50.0)	 5 (50.0) 5 (50.0)	 0.20

Discussion

Pleural drainage is a very common thoracic procedure and in our centre it has been used in many thoracic diseases associated with pleural effusion or pneumothorax and thoracic trauma associated with haemothorax or pneumothorax.[7-13] The use of chest tube insertion connected to underwater seal bottle which is the conventional and common drainage system is characterised by high cost, and also has the potential risks of immobilising the patient during the period of treatment.[4] Pleural drainage with small bore drain attached to a collapsible bag may seem to be less effective albeit its benefits for patient comfort, mobility and sometimes avoidance of hospital admission have been documented.[2] Our study has corroborated other studies which have shown that small bore ambulatory pleural drain is effective in the treatment of pneumothorax and haemothorax when compared with large bore thoracic catheter connected to underwater seal bottle.[2,14-19] In the same characteristics of patients and pleural fluid collections, this study shows that both systems of pleural drainage performed satisfactorily at the pre-extubation and one month follow-up assessments of respiratory rate, peripheral arterial oxygen saturation, and lung re-expansion which assessed recurrence. Results were also comparable among the two treatment arms for duration of drainage and length of hospitalisation. The urobag which was used in this study has previously been used for same purpose and reported to be effective.[20-22]

One comparative study that has been undertaken and which constituted Grade III evidence, compared a 9F with a 20-32F intercostal tube drain in 67 pneumothoraces and reported that both systems were equally effective in resolving pneumothoraces but with a higher combined prevalence of complications and recurrences in the small-bore pleural drain group.[23,24] However other related studies did not find significant differences in recurrence rate in patients treated with the two drainage systems.[16,17] Among the patients with pneumothorax (table 1) the normalisation of respiratory rate which was faster in the small bore pleural drain group although with statistical difference that was not significant (p=0.058) could not be fully attributed to less chest pain expected in patients having small bore pleural drain when compared to patients having large bore thoracic catheter that impacts more pressure in the tissues of the intercostal space.[3,15] This is because in the patients with haemothorax, normalisation of respiratory rate was faster in the large bore treatment group. Some related studies have found the benefits of small bore pleural drain when compared with large bore chest tube to include less pain with insertion and while the tube is in place.[2,3,15]

The response of peripheral arterial oxygen saturation (SpO_2) to pleural drainage of haemothorax and pneumothorax also confirms the effectiveness of the two drainage systems. Normal SpO_2 [≥95%] was recorded in higher percentages of patients with pneumothorax or haemothorax treated with large bore than patients treated with small bore pleural drain except at the thirty days follow-up assessment when all patients in both treatment groups had normal SpO_2 [tables 1 and 2]

There is a current trend of using smaller calibre (6-12F) intercostal tube drains when attempting to re-expand the lung using an underwater seal. This approach has been advocated by current UK Guidelines[25] produced by the British Thoracic Society (BTS) and a high rate of success has often been quoted.[26] Our current study also corroborates this because the small bore pleural drain and the large bore catheter connected to underwater seal bottle led to complete lung re-expansion before removal of pleural drain in all the patients with pneumothorax or haemothorax. In the study of Vedam and Barnes both tube systems were equally effective in resolving SPNs and concluded that drain calibre did not affect the rate of success.[24] Tsai et al comparing pigtail catheters with large bore chest tubes for management of pneumothoraces found a success rate of 72.5% vs 72.7%.[17] Duration of drainage and length of hospitalisation data analysis showed comparable figures among the two drainage systems for patients with pneumothorax or haemothorax with differences that were not statistically significant. Previous studies comparing the two drainage systems had also shown comparable duration of drainage and length of hospital stay.[17-19] However, duration of drainage and length of hospitalisation were found to be shorter with small bore pleural drains than with large bore chest tubes in some studies.[2,4,14,23] In some selected patients, the use of small bore pleural drains can avert hospital admission.[2,4]

Analysis of complications showed complication rate of 20% (one tube blockage due to blood/fibrin clots and one tube collapse) in the small bore pleural drain group and 10% (one tube blockage due to blood/fibrin clots) in the large bore group. There was no statistically significant difference in the complication rate among the two drainage systems. The analysis of complications by Vedam, et al reported blocked drains in 2.4–14% in the two groups, the largest figure arising in the small-bore drains (14%), tube displacement in 14% of intercostals drains, most occurring with the small tube drains (24%) greater vulnerability of small-calibre tube to forceful displacement (32%) was observed in those patients receiving a large-calibre intercostals drains. These were predominantly insertion site and intra-pleural sepsis, reflecting the likelihood of infection either being introduced during drain insertion or developing over time due to poor stabilisation and anchoring of a large intercostal drains and dressing techniques at the drain site.[24] Our study did not document any case of dislodgement/displacement of the tube from pleural cavity,

disconnection of tube from the drainage bottle, or surgical site infection in the two treatment arms. Larger scale/better designed studies on outcomes of small bore versus large bore pleural drains are needed for greater understanding of their performance.

Conclusion

The use of small bore pleural drains was as equally effective as the use of large bore chest tubes in the management of pneumothorax and haemothorax.

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