Place Atrium to Water Seal (PAWS): Assessing Wall Suction Versus No Suction for Chest Tubes After Open Heart Surgery

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**BACKGROUND** Traditionally chest tubes are set to -20 cm H2O wall suctioning until removal to facilitate drainage of blood, fluid, and air from the pleural or mediastinal space in patients after open heart surgery. However, no clear evidence supports using wall suction in these patients. Some studies in patients after pulmonary surgery indicate that using chest tubes with a water seal is safer, because this practice decreases duration of chest tube placement and eliminates air leaks.

**OBJECTIVE** To show that changing chest tubes to a water seal after 12 hours of wall suction (intervention) is a safe alternative to using chest tubes with wall suction until removal of the tubes (usual care) in patients after open heart surgery.

**METHODS** A before-and-after quality improvement design was used to evaluate the differences between the 2 chest tube management approaches in chest tube complications, output, and duration of placement.

**RESULTS** A total of 48 patients received the intervention; 52 received usual care. The 2 groups (intervention vs usual care) did not differ significantly in complications (0 vs 2 events; \( P = .23 \)), chest tube output (H1 = 0.001, \( P = .97 \)), or duration of placement (median, 47 hours for both groups).

**CONCLUSION** Changing chest tubes from wall suction to water seal after 12 hours of wall suction is a safe alternative to using wall suctioning until removal of the tubes. (Critical Care Nurse. 2017;37[4]:17-28)

After open heart surgery, adult patients have chest tubes inserted to drain excess fluids, air, and blood.\(^1,2\) The placement of a chest tube is necessary to drain fluid or create additional negative-pressure suctioning for lung reexpansion or both.\(^3\) Placement of at least 1 mediastinal tube is traditional, but patients may also have a second pleural tube.\(^4\)
Mediastinal tubes are placed on the surface of the diaphragm into the pericardial well, whereas pleural tubes are placed into the pleural space. The pleural space is a negative-pressure closed system with intrapleural pressures of approximately -4 mm Hg between breaths. This negative pressure allows for and maintains lung expansion during inspiration. Entry of air, fluid, or blood into the space disrupts the negative pressure, and the lung recoils and collapses. Patients undergoing other types of thoracic surgery, such as pulmonary resection, may also have pleural tubes placed postoperatively to prevent pneumothorax and to monitor for air leak and hemothoraces.

In addition, the chest contains the mediastinal cavity, which includes the pericardium. The pericardial space contains a small amount of lubricating fluid. The pericardial space has little capacity to accommodate excess fluids. Excess fluid in or around the pericardium impedes cardiac function by reducing cardiac filling and stroke volume in a condition called tamponade. Tamponade after cardiac surgery occurs when blood and fluids pool in the mediastinal and pericardial cavities and compress the heart.

Drainage tubes placed either in the pleural space after pulmonary surgery or pleural or mediastinal tubes placed after open heart surgery must remain clear and patent to drain effectively. Because of the risk for complications, traditional management of chest tubes for patients after open heart surgery includes use of up to -20 cm H₂O of wall suction to help remove potentially large amounts of drainage and, in patients with pleural tubes, to allow air to leave the chest. Marshall et al indicated that for pulmonary patients, no clear evidence supports managing chest tubes with the use of wall suction and that a water seal is a safe alternative. Whether the same alternative would be safe for patients who have pleural chest tubes after open heart surgery has not been studied.

In a systematic review of the use of mediastinal chest tubes in patients after cardiac surgery, Wallen et al found insufficient supporting evidence for different methods of drainage clearance when various levels of suctioning or suctioning in combination with stripping, fan folding, or tapping chest drains were compared. Current practice includes avoiding vigorous milking or stripping, which can create extremely high negative pressures. However, we found no studies of patients after open heart surgery that compared wall suction and water seal for drainage clearance for mediastinal chest tubes or for managing pleural tubes. The water seal chamber in a closed drainage system does prevent air and fluid from flowing back into the pericardial and pleural space.

What is known is that the management of chest tubes varies and affects the length of time the tubes are in place, pain management, overall hospital length of stay, early mobilization of patients, and type of nursing care needed. Thus, an evidence-based approach for the type of suctioning used in managing chest tubes is important for achieving the best outcomes.

### Background

No known research supports managing chest tubes in patients after open heart surgery by using -10 to -20 cm H₂O wall suctioning from immediately after surgery until the tubes are removed, and this practice most likely is associated with the facility where the surgeon trained rather than scientific evidence. Studies on chest tubes in patients after open heart surgery have primarily focused on the duration of placement of chest tubes and not on the use of suctioning in the association of these factors with postoperative complications.

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Specifically, in 2 studies, researchers examined the timing of chest tube removal and tested whether removing chest tubes on the first versus the second postoperative day was a safe approach. The findings indicated that chest tube removal on the first postoperative day is potentially a safe practice. In a recent study on the use of a single chest tube versus multiple chest tubes in cardiac surgery patients, usual practice was to discontinue all chest tubes within 24 hours of surgery unless complications occurred.

However, in clinical practice chest tubes often remain in place until the second postoperative day, because recommendations from current guidelines for open heart surgery focus on the amount of drainage (ie, <100 mL/8 h) as an important factor for determining removal. These guidelines, which primarily stem from expert opinion and practice experience, also specify that prolonged placement of chest tubes may actually increase total chest tube output and not decrease the incidence of postoperative pericardial effusions, so although drainage is a factor in removal of chest tubes, timely removal is also important.

Studies on the use of wall suction have been done in patients after pulmonary surgery in whom chest tubes are also placed to prevent pneumothorax and to remove excess fluid or air or both. Specifically, Cerfolio et al and Marshal et al found that for pulmonary surgery patients, placing chest tubes to water seal was potentially a better practice than using wall suction. Cerfolio et al determined that water seal was superior to wall suction for eliminating air leaks. Deng et al concluded in a meta-analysis of outcomes of wall suction versus water seal after pulmonary surgery that in most cases use of wall suction was of no benefit as a strategy to reduce the incidence of prolonged air leaks. More specifically, the analysis of multiple studies in this meta-analysis indicated that patients with chest tubes with continuous negative-pressure wall suction had longer duration of tube placement before removal of the tubes than did patients with chest tubes with a water seal, a situation that ultimately increased the hospital length of stay.

However, Deng et al also determined that negative-pressure wall suction might prevent a postoperative pneumothorax due to development of an air leak early in the postoperative course for specific patients. In a systematic review of the effectiveness of suction versus water seal for optimal management of pleural chest tubes in adult patients, Hawley et al found that water seal alone reduced duration of air leak, duration of chest tube placement, and hospital length of stay. Marshall et al concluded that placing chest tubes to water seal after a brief period of negative wall suction after pulmonary surgery was a factor in decreasing both air leaks and the length of time the chest tubes were in place. Thus, although evidence from pulmonary surgery studies provides some support for using water seal for patients who have pleural tubes placed after open heart surgery, some indication may exist for still using chest tubes with wall suction for a limited time early in the postoperative period to guard against a pneumothorax.

In a systematic review, Wallen et al found that few researchers had examined the best methods for managing drainage via mediastinal chest tubes and did not find differences in chest tube output or incidence of tamponade for different levels of suctioning and manipulation techniques of the tubes. In a study of 234 patients who had coronary artery bypass grafting, Wynne et al found that the amount of chest tube drainage plateaued to 31 mL/h at 8 hours after surgery and to 21 mL/h after 24 to 48 hours. In addition, Kuvin et al found that in 4561 patients undergoing open heart surgery, the rate of cardiac tamponade was 0.2% in patients who had coronary artery bypass grafting and 0.6% in patients who had grafting plus valve replacement. Thus, a decrease in chest tube output 8 hours after surgery, the lack of evidence for specific drainage management methods for mediastinal chest tubes, and the low rate of tamponade for patients after open heart surgery may indicate the potential for safely using other management processes that facilitate early removal of chest tubes.

**Intended Improvement**

On the basis of the literature review for pleural and mediastinal chest tubes and our experience at Abbott Northwestern Hospital, Minneapolis, Minnesota (ANW), of placing chest tubes of thoracic surgery patients to water seal at midnight on the first postoperative day without adverse events, we deemed that a similar practice was reasonable for patients who had open heart surgery. However, potential risks, as well as the benefits of placing
chest tubes to water seal after open heart surgery, are important to understand before a change in practice is fully adopted. Thus, our primary goal in this quality improvement study was to demonstrate that compared with the current practice of placing chest tubes to -20 cm H₂O wall suction until tube removal, placing chest tubes to water seal at 6 AM the morning after open heart surgery is a safe alternative for chest tube management and would not result in significant differences in complications. For this study, we compared the development of new air leaks, chest tube drainage, time of chest tube removal, and occurrence of a pericardial/pleural effusion or bleeding around the chest tube sites requiring intervention associated with the 2 approaches for managing chest tubes.

Study Question
We designed the study to answer the following evidence-based practice (EBP) question that specified a patient or problem, an intervention, a comparison group, and outcome (PICO):22 For adult patients undergoing open heart surgery, does a difference exist in complications associated with chest tubes, measured drainage output, and duration of tube placement when chest tubes remain connected to wall suction until discontinued (usual care) versus placing chest tubes to water seal at 6 AM the morning after surgery?

Methods
Design
We used a before-and-after design for the study. The before phase occurred in May 2014 and included selected open heart surgery patients with chest tubes managed by using -20 cm H₂O wall suction until the tubes were removed. The after phase occurred June 2014 and included a second group of open heart surgery patients who had water seal as part of the protocol for managing chest tubes. Before the study began, an interprofessional EBP team obtained approval from the cardiac surgeons for a protocol for placing chest tubes to water seal and developed a data collection instrument for documenting chest tube output, duration of tube placement, and complications for the 2 groups of patients.

Ethics
The appropriate institutional review board deemed that the project did not meet requirements for human subject research and did not require approval from the board. However, the quality improvement protocol included collecting data on patients who had open heart surgery from electronic medical records in which alphanumeric codes were used to replace patient names to maintain confidentiality. Only data from open heart surgery patients who signed the general hospital admission consent giving permission to use their health information in research and quality improvement were included in the study.

Setting
The sample consisted of patients from the cardiovascular surgery intensive care unit (CVICU), a 16-bed Beacon unit at ANW. ANW is a 626-bed nonprofit Magnet hospital that serves the immediate urban population in addition to people living in a 5-state region. Cardiac surgery at the hospital is a high-volume adult-only program. Approximately 875 surgeries were performed in 2014, including minimally invasive heart procedures. For our study, we excluded patients who received left ventricular assist devices or heart transplants, because of these patients’ greater variability in care needs and requirements.

Planning and Implementing the Intervention
Traditionally, for patients who have had open heart surgery, nurses at ANW have placed chest tubes to -20 cm H₂O wall suction immediately upon the patients’ arrival in the CVICU and have maintained the suction at this level until removal of the chest tubes, which generally occurs on the second postoperative day. A staff nurse from the CVICU attended a presentation at a national conference that served as inspiration for changing our practice of using negative-pressure wall suction for open heart surgery patients to include the use of a water seal. The staff nurse submitted an application to participate in the hospital’s EBP fellowship program for nursing based on the interprofessional EBP partnership program at St. Catherine University, Saint Paul, Minnesota. In this 18-month fellowship program at ANW, selected staff nurses (approximately 3-5 nurses per cohort) from a wide variety of nursing units, including rehabilitation, obstetrics, medical-surgical, and critical care, become EBP fellows. Each fellow works with a clinical nurse specialist as a mentor in a team of interprofessional faculty and students from St. Catherine University to address important clinical questions. Attendees of the program participate
in an educational program on EBP, implementation science, and team-based practice. The strength of the program is the inclusion of interprofessional expertise and perspectives within a team to develop a practice change.

The initial step for our quality improvement study was to review publications on current research and clinical practice. For the search, we used PubMED/MEDLINE, OVID, Cochrane Library, and Mosby’s Nursing Skills and the search terms chest tubes, open-heart surgery, drainage, suction, heart, cardiac surgery, postoperative, water seal, management, complications, open heart surgery, thoracic surgery, chest tube practices, mediastinal chest tubes, and pleural chest tubes. We included publications from 1980 through 2013. Because we anticipated that few studies would include the PICO questions, our search strategy included a wide date range. The search produced 128 sources with some clinical relevance to managing chest tubes. None of the studies we found directly answered the PICO question. Specifically, researchers examined the use of water seal versus wall suction in only 11 studies, and none of those 11 included patients who had open heart surgery. An updated search that included material published in 2014 through 2016 produced only 3 additional articles; 1 was a systematic review with a meta-analysis, and 2 were narrative review articles on the use of water seals.5,23 No new information was gained from these additional sources.

After synthesizing evidence from research on pleural and mediastinal chest tubes, expert practice recommendations, and experience at ANW in safely managing chest tubes with a water seal for thoracic surgery patients, the interprofessional EBP team designed an implementation plan for testing a similar practice for patients after open heart surgery. Specifically, the team used the drivers of change, which are evidence-based factors necessary for successful implementation. Fixsen et al24 identify drivers as facilitative administrative and stakeholder support, system interventions, preservice training, consultation and coaching at the point of care, and staff and program evaluation. The team used these factors to design the implementation of the project, creating strategies related to each driver (Table 1). In the implementation model of Fixsen et al, 2 factors (intervention and implementation components) ensure effective implementation of a practice change. Intervention components are the essential elements of an intervention necessary for a patient to receive a demonstrated benefit, and implementation components are the essential strategies that ensure adoption of the intervention.

The EBP staff nurse fellow and the clinical nurse specialist mentor led the implementation phase of the

<table>
<thead>
<tr>
<th>Driver</th>
<th>Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilitative administrative and stakeholder support</td>
<td>Established leadership for implementation Obtained approval and support of cardiac surgeons Obtained approval and support from the intensive care unit interdisciplinary practice committee Garnered support from nurse managers of intensive care and telemetry units Communicated with nurse practitioners managing postoperative care and with nurse educators Discussed study with staff nurses</td>
</tr>
<tr>
<td>System interventions</td>
<td>Developed inclusion and exclusion process for identifying patients appropriate for using water seal Developed protocol for decision making for the use of water seal Developed and did a trial of a data collection form Named the project PAWS Developed PAWS stickers and posters to increase use of protocol</td>
</tr>
<tr>
<td>Preservice training and ongoing staff education</td>
<td>Nurse managers sent weekly emails</td>
</tr>
<tr>
<td>Consultation and coaching</td>
<td>Rounded at 6 AM-7 AM on the use of the protocol Answered staff questions</td>
</tr>
<tr>
<td>Staff and program evaluation</td>
<td>Tracked and reviewed the data collection sheets Addressed missing data elements</td>
</tr>
</tbody>
</table>

No known research supports using wall suction until chest tube removal.
Stakeholders for the project included cardiac surgeons, nurse practitioners, staff nurses, nurse managers, and nurse educators who provided additional input for the project. The CVICU interprofessional practice committee approved the study plan, and the staff nurse EBP fellow met with CVICU and telemetry nursing leaders to garner their support. To facilitate communication and awareness, the interprofessional EBP team named the study the PAWS project, an acronym for place atrium to water seal.

Resources and materials for the project included a data collection form to track outcomes for open heart surgery patients in both phases of the study. Data included type of surgery, time of arrival to the CVICU, number of chest tubes, chest tube output, time of chest tubes removal, and complications (Figure 1). The project also included designing a chest tube protocol in the form of an algorithm for the intervention study phase to provide guidance for placing chest tubes to water seal (Figure 2). The protocol did not distinguish mediastinal...
from pleural chest tubes for placement to a water seal, because tubes are often connected to the same drainage container. The interprofessional EBP team determined that maintaining suction for a minimum of 12 hours during the intervention phase was the best approach according to consultation with the surgeons and the results of the study by Marshall et al., which indicated some benefit for a short period of wall suction for patients with pleural tubes. The 12-hour period allowed caregivers time to monitor the amount of drainage, watch for tamponade, and determine the presence of an air leak for patients with plural chest tubes.

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**Figure 2** The PAWS quality improvement protocol.

Abbreviations: CAB, coronary artery bypass; CT, chest tube; fibrillation; POD, postoperative day; TAVR, transcatheter aortic valve replacement; VAD, ventricular assist device.
The bedside nurses then evaluated open heart surgery patients at 6 AM on the first postoperative day to determine whether the patients met criteria to place chest tubes to water seal. The 6 AM time the morning after surgery was selected to switch to water seal because most patients are back from surgery before 6 PM the day of surgery, and placing chest tubes to water seal at 6 AM allowed for 12 hours of wall suction. In addition, the team assumed that patients not back from surgery by 6 PM potentially would still have chest tube output greater than 150 mL/h (see Figure 2 for the criteria for chest tube output). Thus, the exclusion criteria included open heart surgery patients who arrived in the CVICU from surgery after 6 PM, because these patients would not have had 12 hours of wall suction.

Nurses kept chest tubes to wall suction if a patient had an air leak, an open chest, or chest tube output greater than 150 mL/h for 2 consecutive hours between 2 AM and 6 AM. The 2-hour inclusion criteria for evaluating chest tube output accounted for patients who experienced a single episode of high-volume chest tube output related to changes in body position when first getting up versus patients with continued elevated output due to active bleeding. Patients who did not meet the criteria at 6 AM were not reevaluated later, and the nurses managed those patients’ chest tubes by using traditional negative-pressure wall suction. Nurses conducted ongoing assessments for continuing the use of a water seal until the chest tube was removed. If a patient had complications, nurses returned the chest tubes to negative-pressure wall suction. The EBP fellow designed and placed stickers on patients’ charts and chest tubes during the intervention phase to remind staff of the study and the need to evaluate at 6 AM whether or not the patient met criteria for placing chest tubes to water seal.

The CVICU nurses were responsible for the initial evaluation and transition of the chest tubes to water seal, and because open heart surgery patients routinely are transferred early in the morning the first postoperative day, the removal of the chest tubes generally occurred on the telemetry unit. As a result, the EBP staff nurse fellow provided education to both CVICU and telemetry nursing staff, using weekly emails from the nurse manager and educators to provide information. To provide ongoing staff consultation and feedback on implementation of the chest tube protocol, the EBP staff nurse fellow and the clinical nurse specialist mentor made rounds on the postoperative patients early in the morning to increase awareness and answer questions. Nursing staff assisted the EBP fellow in completing the data collection forms.

Interrater reliability was not established. However, all staff members were trained on completing the data collection form and on the method for measuring chest tube output at the times listed on the form. The EBP fellow reviewed all of the forms and addressed unclear information with the staff nurses and used the electronic health record to address missing or incomplete data.

Evaluation and Analysis

Differences in chest tube output, duration of chest tube placement, and complications before and after implementation of the change in practice were determined. A priori, statistical significance was set at $\alpha = .05$. Stata, version 11.2, software (StataCorp LLC) was used for all statistical analysis. Depending on the type of data (continuous vs categorical), initial analysis included various descriptive statistics to describe the characteristics of the 2 groups of open heart surgery patients (phase 1, usual care and phase 2, change to water seal). Methods used to determine differences between the 2 groups in patient characteristics included $t$ tests, $r^2$ analysis, and the Fisher exact test.

Outcome variables were described by using descriptive statistics: means and standard deviations for continuous variables and percentages for categorical variables (Table 2). When continuous variables had skewed distributions, data summaries included medians and the 25th and 75th percentiles. Complications for both groups included the combined percentage of patients with an air leak, high-volume chest tube output, and excessive bleeding around the chest tube site. For data collected after the intervention phase, the analysis also included the percentage of open heart surgery patients in whom the chest tube was not removed and wall suction was continued. Differences in outcomes between groups were compared by using $t$ tests for normally distributed variables, the Kruskal-Wallis test for continuous variables with nonnormal distribution, and the Fisher exact test or $\chi^2$ analysis for categorical variables.
Results

The samples initially consisted of 52 patients in the phase 1 group (usual care; before the intervention) and 56 patients in the phase 2 group (change to water seal; after the intervention). In the phase 2 group, 48 patients (86%) had chest tubes placed to water seal, and 8 patients (14%) had chest tubes that remained connected to wall suction. The reasons for not placing chest tubes to water seal were an air leak (n = 3), drainage (n = 2), and reasons categorized as other (n = 3). We found no significant differences between patients in the phase 1 group (n = 52) and patients in the final phase 2 group (n = 48) for age, surgery type, and number of mediastinal and pleural chest tubes. The only significant difference was sex; the phase 1 group had more men in the sample than did the phase 2 group (Table 3).

The 2 groups of patients did not differ significantly for total hours chest tubes were in place (median, 47 hours for both groups), the number of patients who had chest tubes discontinued after postoperative day 2 (10 in phase 1; 9 in phase 2), or for reasons the chest tubes were not removed (Table 4). In addition, the 2

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Table 2 Demographics and differences between groups before and after implementation of the intervention

<table>
<thead>
<tr>
<th>Variable</th>
<th>Before* (n = 52)</th>
<th>After* (n = 48)</th>
<th>df</th>
<th>Test value</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD), y</td>
<td>67.2 (11.7)</td>
<td>65.5 (11.5)</td>
<td>98</td>
<td>-0.729b</td>
<td>.47</td>
</tr>
<tr>
<td>Male, No. (%)</td>
<td>39 (75)</td>
<td>26 (54)</td>
<td>1</td>
<td>4.8c</td>
<td>.03</td>
</tr>
<tr>
<td>Surgery type, No. (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coronary artery bypass</td>
<td>25 (48)</td>
<td>15 (32)</td>
<td>2</td>
<td>4.132d</td>
<td>.14</td>
</tr>
<tr>
<td>Combo</td>
<td>1 (2)</td>
<td>4 (9)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valve</td>
<td>26 (50)</td>
<td>28 (60)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mediastinal chest tube, No. (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>3 (6)</td>
<td>1 (2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>24 (48)</td>
<td>20 (42)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>22 (44)</td>
<td>25 (52)</td>
<td></td>
<td>1.848d</td>
<td>.61</td>
</tr>
<tr>
<td>3</td>
<td>1 (2)</td>
<td>2 (4)</td>
<td></td>
<td></td>
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<td>Pleural chest tube, No. (%)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>0</td>
<td>19 (37)</td>
<td>26 (54)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>21 (40)</td>
<td>16 (33)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2</td>
<td>12 (23)</td>
<td>6 (12)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Number of patients do not total 52 or 48 for some missing data. Not all percentages total 100 because of rounding.

b Student t test.

c χ² analysis.

d Fisher exact test.

Table 3 Chest tube placement time, time discontinued, reason not discontinued, and complications for patients before and after implementation of the intervention

<table>
<thead>
<tr>
<th>Variable</th>
<th>Before (n = 52)</th>
<th>After (n = 48)</th>
<th>df</th>
<th>Test value</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest tube total time, median (25th, 75th percentile), h</td>
<td>47 (46, 52)</td>
<td>47 (45, 49)</td>
<td>1</td>
<td>0.456a</td>
<td>.50</td>
</tr>
<tr>
<td>Chest tube discontinued after postoperative day 2</td>
<td>10 (19)</td>
<td>9 (19)</td>
<td>1</td>
<td>0.001a</td>
<td>.99</td>
</tr>
<tr>
<td>Reason chest tube was not discontinued</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output too high</td>
<td>4 (40)</td>
<td>4 (44)</td>
<td>2</td>
<td>0.1b</td>
<td>.97</td>
</tr>
<tr>
<td>Air leak</td>
<td>1 (10)</td>
<td>1 (11)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Other risk</td>
<td>5 (50)</td>
<td>4 (44)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any complication</td>
<td>0 (0)</td>
<td>2 (4)</td>
<td>1</td>
<td>2.211c</td>
<td>.23</td>
</tr>
</tbody>
</table>

a Kruskal-Wallis test.

b χ² analysis.

c Fisher exact test.
groups did not differ significantly in chest tube output for each of the 5 measured periods and for the total postoperative output. A Kruskal-Wallis H test indicated no significant difference in overall total output between the 2 groups ($H_1 = 0.001; P = .97$); median output was 408 mL for the phase 1 group and 423 mL for the phase 2 group. According to the Fisher exact test, the 2 groups did not differ significantly in complications: 0 events in the phase 1 group and 2 events in the phase 2 group ($P = .23$).

**Discussion**

In this quality improvement project, we found no significant differences in chest tube drainage, duration, and complications between patients after open heart surgery who had chest tubes with wall suction until removal of the tubes and patients who had chest tubes changed to water seal after 12 hours of wall suction. These results provide evidence that placing chest tubes to water seal after a period of suction is a safe practice.

Although patients with an air leak were excluded from our study, other researchers found that placing chest tubes to water seal for pulmonary patients actually decreased the duration of the air leak or had no impact on the incidence of a prolonged air leak. Cerfolio et al stopped their randomized control trial because of the clinical benefits and statistically significant results for postoperative pulmonary patients with chest tubes placed to water seal.

In a meta-analysis, Deng et al demonstrated that pulmonary patients with chest tubes placed to wall suction had a longer time to chest tube removal and longer length of hospital stay than did patients with chest tubes placed to water seal. Our findings did not indicate that same difference for time to chest tube removal. However, discontinuing chest tubes requires an order from a care provider and often depends on the timing of physician rounds. In our study, removing chest tubes depended on the amount of chest tube drainage. The lack of difference in the amount of drainage between our 2 groups of patients may explain our insignificant findings. However, the finding that open heart surgery patients with chest tubes to water seal did not have excessive drainage also supports the safety of the practice.

Among our patients, 2 patients in the phase 2 group had air leaks that required a return to wall suction. However, in retrospect, placement of chest tubes back to suction for an air leak is not necessarily a complication associated with using a water seal. We had no documentation available for the 2 patients who had air leaks to determine whether the air leak continued or resolved with negative-pressure wall suction. Studies in patients undergoing pulmonary surgery have revealed benefits of using water seal rather than suction in decreasing the air leak. Some researchers suggest that wall suction may actually hinder the sealing process, leading to an increase in the volume of air leaking from the parenchyma.

Using the drivers of implementation of Fixsen et al was an effective method for ensuring the fidelity of the intervention (ie, use of water seal per study protocol). Creating a protocol that guided staff in using a water seal that included decision-making criteria helped clarify the essential components of the intervention. The

<table>
<thead>
<tr>
<th>Time of output*</th>
<th>Before (n = 52)</th>
<th>After (n = 48)</th>
<th>Kruskal-Wallis</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>From arrival to 4 hours postoperatively</td>
<td>188 (111, 328)</td>
<td>215 (135, 318)</td>
<td>0.412</td>
<td>0.52</td>
</tr>
<tr>
<td>Day 1, 2 AM-6 AM</td>
<td>70 (45, 110)</td>
<td>70 (40, 90)</td>
<td>0.001</td>
<td>0.98</td>
</tr>
<tr>
<td>Day 1, 11 PM-7 AM</td>
<td>123 (90, 175)</td>
<td>123 (79, 170)</td>
<td>0.031</td>
<td>0.86</td>
</tr>
<tr>
<td>Day 1, 7 AM-3 PM</td>
<td>100 (70, 130)</td>
<td>90 (60, 135)</td>
<td>0.456</td>
<td>0.50</td>
</tr>
<tr>
<td>Day 1, 3 PM-11 PM</td>
<td>70 (35, 100)</td>
<td>85 (50, 130)</td>
<td>1.623</td>
<td>0.20</td>
</tr>
<tr>
<td>Day 1, total</td>
<td>314 (230, 370)</td>
<td>305 (240, 400)</td>
<td>0.133</td>
<td>0.72</td>
</tr>
<tr>
<td>Day 2, total</td>
<td>340 (240, 495)</td>
<td>270 (170, 550)</td>
<td>0.611</td>
<td>0.43</td>
</tr>
<tr>
<td>Day 3, total</td>
<td>310 (230, 370)</td>
<td>275 (135, 473)</td>
<td>0.240</td>
<td>0.62</td>
</tr>
<tr>
<td>Total output</td>
<td>408 (275, 725)</td>
<td>423 (310, 605)</td>
<td>0.001</td>
<td>0.97</td>
</tr>
</tbody>
</table>

* All values are median (25th, 75th percentile), mL. Degrees of freedom = 1 for all statistical tests.
use of an acronym for improving staff awareness of the study and study processes was an essential implementation component. Specifically, the acronym PAWS was useful in creating visibility, reminded busy staff about the quality improvement study, and facilitated questions from staff members. Early morning rounding provided an opportunity for coaching and provided staff support in changing practice. As a result, nursing staff were supportive of the use of a water seal. Staff support was essential for incorporating the practice change into the postoperative order set at ANW and for disseminating the practice to 2 other hospitals within the system.

A unique feature of our study was the collaboration and learning that occurred with the interprofessional team in the EBP fellows program. The EBP fellow, clinical nurse specialist mentor, students, and faculty members of the interprofessional team brought different knowledge, both complimentary and unique skills for conducting EBP and research, and different perspectives to ensure effective implementation of a practice change. Sharing the work, learning from personnel in various disciplines, and taking the opportunity to teach each other made completion of the project possible.

Limitations

A potential limitation for the study is that the sample size was not based on a power analysis, and a study with a larger sample size might have different results. However, sample sizes as low as 25 have been identified as appropriate for quality improvement studies.19 Because inter-rater reliability was not specifically established for the staff members who collected data, data collection might have been inconsistent. However, staff education, coaching, and careful review of each form minimized the potential for inaccurate data. In addition, because the study included a single CVICU unit within a single setting, the results may have limited generalizability. Our study was conducted in a Magnet facility, a situation that may have positively affected the implementation process, because the facility has a culture supportive of research and EBP. In addition, ANW has a large cardiovascular surgery program, and because of the high numbers of surgeries, caregivers have extensive experience that may have also positively affected outcomes associated with using a water seal in patients after open heart surgery. However, our results are similar to the findings in other studies, thus providing additional evidence for managing chest tubes differently.

Conclusion

The results of this quality improvement study indicated that placing chest tubes to water seal after 12 hours of negative-pressure wall suction in patients after open heart surgery is a safe alternative to using wall suction until chest tubes are removed. Only 2 patients required renewal of wall suction, because of the presence of air leaks. The use of implementation drivers and an interprofessional team facilitated implementation of the practice change, ensuring the fidelity of the intervention. Future studies are needed to examine whether the use of water seal for patients after open heart surgery facilitates early ambulation, has psychological benefits associated with not being tethered to wall suction, reduces hospital length of stay, and increases the amount of time staff members have for providing care.

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See also


References


Place Atrium to Water Seal (PAWS): Assessing Wall Suction Versus No Suction for Chest Tubes After Open Heart Surgery
Tamara Kruse, Sharon Wahl, Patricia Finch Guthrie and Sue Sendelbach

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