DIGITAL, SMART, PORTABLE CHEST DRAIN PUMPS

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Introduction

- Evolution of drainage systems
- Advantages and disadvantages of water-seal and digital drainage systems
- Evidence supporting transition to digital systems
- Current recommendations
• Drainage of thoracic cavity is known since Hippocrates (460 – 370 BC)
• Initial use for empyema and haemorrhax (military thoracic trauma)
• For more than 2000 years chest drains were draining either through gravity or by suction applied via mouth or suction pumps
• 1771: First drain connected to reservoir container (Adamus Birkholz)
• 1873: First water-seal chest drainage system for treatment of empyema to a child
• 1875: First closed water-seal chest drainage system (Gotthard Bülau)
• World War I: Use of flutter valve for unidirectional air movement

Sarah Walcott-Sapp, Mithran Sukumar: “A history of Thoracic Drainage: from Ancient Greece to Wound Sucking Drummers to Digital monitoring”
History

- 1910: First use of vacuum pumps connected to drainage system (Samuel Robinson)
- 1929: First described use of suction post-lobectomy (Brunn)
- World War II: 2-bottle water-seal suction system post-thoracotomy
- 1952: First description of 3-chamber thoracic drainage system (Howe)
- 1968: Heimlich designed the flutter valve attached to drains
- 3-chamber single unit drainage systems was adopted as the most appropriate and easy to use for the last few decades
- Evolution led to the introduction of Digital drainage systems since 2007

Sarah Walcott-Sapp, Mithran Sukumar: “A history of Thoracic Drainage: from Ancient Greece to Wound Sucking Drummers to Digital monitoring”
Chest drainage systems
Why such variety?

- Variety of use
  - Air
  - Fluid
  - Blood
  - Pus
  - Chyle
- Better understanding of respiratory function
- Better understanding of pleural physiology
- Need for decreasing hospital stay
- Optimization of financial status
Closed water-seal chest drainage system

Advantages

- Easy and quick application (collector with/without connecting tube, sterile water)
- Available in any unit dealing with chest drains (Cardiothoracic, A&E, ICU, Upper GI, Theatres)
- Immediate feedback that drain is in the pleural cavity (obvious swinging)
- Easy to communicate with colleagues and easy to teach
  - Bubbling → Air leak
  - Level of fluid → Total drainage
- Easy to realize that drain is functional (swinging)
- Low cost equipment
Closed water-seal chest drainage system

Disadvantages

- Prone to accidents
- Multiple tubes and collectors when more than one drains required (depends on firm)
- Close monitoring in order to identify that drain is disconnected or blocked
- Difficult to identify when air leak has stopped
- Difficulty in sharing information and teaching
- Complex connections in case that suction needed and prone to mistakes on regulating suction (cmH2O, mmHg, kPa)
- Difficulty in mobilization of patients away from beds, especially when more than 1 drains or suction required
- Subjective view in decision making for drain removal, so difficult to apply protocols
Digital drainage systems

**Advantages**

- Resistance to accidents. It continues to function even when pump is off
- Easy connections in case than more than 1 drains required
- Alarms for drain disconnection or occlusion
- Easy to identify when air leak has stopped
- Easy information sharing and teaching
- Portable suction with easy adjustment
- Quick and easy mobilization of patients away from their beds
- Objective view in decision making for drain removal, so easy to apply protocols
- Quantification of air leak
- Storage of data for each patient (history of air leak and fluid drainage charts)
- Available software for exporting data for research purposes
Digital drainage systems

Disadvantages

- More complex preparation (calibration, checking of connections)
- Requires electric supply
- No immediate feedback that drain is in the pleural cavity (no fluid drainage means no swinging)
- Not available in any unit dealing with chest drains
- Fluid output monitoring may not be reliable in case of high air leak
- High cost equipment
- Not appropriate for pneumonectomies
### Complexity in suction connection

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<tr>
<td>Thoracic suction unit only</td>
<td>Navy lid VacSax® only.</td>
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- NEVER use Black or Green-lidded VacSax®
- Fill with sterile water to ‘0’/Prime level line

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*Guidelines For The Management A Patient With Underwater Seal Chest Drainage Final November 2015 Amended and ratified by EBPC 28/09/17 Review 2018*
Mori et al: "Assessment of pleural air leakage using digital chest drainage system after surgical pulmonary resection: Comparison of visible alveolar air leakage with the digital value measured by a digital chest drainage system"; doi.org/10.1371/journal.pone.0187705
Filosso et al: "Digital versus traditional air leak evaluation after elective pulmonary resection: a prospective and comparative mono-institutional study"; Journal of thoracic disease; Vol 7; No10 (October 2015)
Digital drainage systems
Do we really need them?

Key points in Thoracic Surgery

- Early postoperative mobilization is of significant importance after thoracic operations (low incidence of atelectasis, sputum retention, infections, thromboembolic events)
- Prolonged air leak is a common postoperative complication, associated with prolonged hospital stay and higher cost
- There is no evidence to support superiority of suction after lung resection. However, it is a common practice and preference among thoracic surgeons (1)
- There are no protocols or common practice in the postoperative management of chest drains. It has been an empirical practice for years

Cerfolio et al: “The benefits of continuous and digital air leak assessment after elective pulmonary resection: a prospective study”


- 100 Patients

Conclusions

“The digital and continuous measurement of air leaks instead of the currently used static analogue systems reduces hospital length of stay by more accurately and reproducibly measuring air leaks. This leads to quicker chest tube management decisions because the average size of an air leak during the last several hours can be determined. Intrapleural pressure curves may also help predict the optimal chest tube setting for each patient’s air leak and eliminate the need for chest roentgenograms”
13 studies were published in period 2010 – 2016

- 11 in patients with pulmonary resection (lobectomy, segmentectomy, wedge)
  - 5 Randomized Controlled Trials
  - 3 Observational Comparative Studies with propensity matched controls
  - 3 Observational Non-comparative studies

- 2 in patients with pneumothorax
  - 1 Randomized Controlled Trial
  - 1 Observational Non-comparative case series

No blinded studies
Endpoints

- Duration of air leak
- Length of hospital stay
- Complications related to drains
- Re-insertion of chest drain
- Early and easy mobilization
- Patients’ satisfaction
Duration of chest drain placement

No significant difference
- 4 RCTs

Significant difference
- 2 RCTs
- 3 Observational Comparative Studies with propensity matched controls
Length of hospital stay

No significant difference
- 4 RCTs

Significant difference
- 2 RCTs
- 3 Observational Comparative Studies with propensity matched controls
Postoperative complications

No significant difference
- 2 RCTs
- 1 Observational Comparative Study with propensity matched controls

Significant difference
- 1 RCT
- 1 Observational Comparative Study with propensity matched controls
Chest drain re-insertion

No significant difference
- 3 Observational Comparative Studies with propensity matched controls
- 2 RCT showed higher number of drain re-insertion in the water-seal drainage group and no drain re-insertion in the digital drainage group

Significant difference
- None
Early and easy mobilization and patients’ satisfaction

- They were investigated by only 2 studies
  - 1 RCT and 1 Observational Non-comparative case series
  - They both provided positive feedback for early mobilization, improved ability and flexibility to mobilize
  - General comments of satisfaction in patients’ questionnaires
Gilbert et al: “Randomized trial of digital versus analog pleural drainage in patients with or without a pulmonary air leak after lung resection”

*J Thorac Cardiovasc Surg; 2015 Nov;150(5):1243-9*

- 172 patients

**Conclusions**

“Although digital devices decreased tube clamping trials, the impact on duration of chest tube drainage and hospital stay was not statistically significant, even after stratifying by postoperative air leak status”
Study comparing 2 digital and 1 water-seal drainage systems

Mier JM et all: “The benefits of digital air leak assessment after pulmonary resection: prospective and comparative study”

Cir Esp; 2010 Jun;87(6):385-9

- 75 Patients
- Well-matched comparative groups of patients
- 2 different digital drainage systems

Conclusions

“The digital and continuous measurement of air leak instead of the currently used static analogue systems reduced the chest tube withdrawal and hospital stay by more accurately and reproducibly measuring air leak. Intrapleural pressure curves from the Digivent may also help predict the optimal chest tube setting for each patient. The Thopaz alarm mechanism is very useful to prevent deficiencies in the mechanism and do not required wall suction”
Pompili et al: “Multicenter international randomized comparison of objective and subjective outcomes between electronic and traditional chest drainage systems”

*Ann Thorac Surg; 2014 Aug;98(2):490-6*

- 381 patients
- Well designed study
- Including lobectomies and segmentectomies

**Conclusions**

“Patients managed with digital drainage systems experienced a shorter duration of chest tube placement, shorter hospital stays, and higher satisfaction scores compared with those managed with traditional devices”
Michele de Waele et al: “Does the usage of digital chest drainage systems reduce pleural inflammation and volume of pleural effusion following oncologic pulmonary resection?—A prospective randomized trial”

*J Thorac Dis; 2017 Jun; 9(6): 1598–1606*

- 103 patients

**Conclusions**

“Use of post-lung resection digital drainage does not appear to decrease pleural fluid formation, but is associated with decreased prolonged air leaks. Total pleural effusion volumes did not differ with the type of drainage system used”
The case for adopting Thopaz+ for managing chest drains is supported by the evidence. Thopaz+ can reduce drainage time and length of stay in hospital, and improves safety for people with chest drains. Its use may also improve clinical decision-making through continuous, objective monitoring of air leaks and fluid loss.

Thopaz+ should be considered for people who need chest drainage after pulmonary resection or because of a pneumothorax. The system can increase patient mobility because it is portable. Staff find it more convenient and easier to use than conventional chest drains.

Cost modelling indicates that Thopaz+ is cost saving compared with conventional chest drains in people after pulmonary resection. The estimated saving is £111 per patient per hospital stay, with savings mainly achieved through reduced length of stay. The NICE resource impact assessment shows that, at a national level, adopting Thopaz+ is expected to save around £8.5 million per year in England.
Conclusions

Digital drainage systems

- Safe, when staff trained appropriately
- Easy to use
- Objective decision making and protocol application
- Increase mobility of patients
- May reduce duration of drain and length of hospital stay, but do not improve prolonged air leak and fluid output
- Cost-effective in high volume Cardiothoracic units