medela


# Latest evidence

## Digital Chest Drainage Systems

Precious life,
progressive care

# 10 years of digital


Robotics, artificial intelligence, telemedicine, health apps and much more. The digital revolution is not bypassing the medical field. Quite the opposite: it is quickly heading towards our day-to-day work and influencing how we work in the OR, the ICU and on the ward.

And chest drainage systems have already started to become digital. These systems are used in many fields in acute and emergency medicine. They are set up to provide optimal therapy for the patient.

Digital chest drainage had its tenth anniversary in 2018. Traditional systems that rely on external wall suction have long been outdated. The digital chest drainage and monitoring system Thopaz/Thopaz+ was used to treat 70 % of all patients in Germany [1] after cardiothoracic surgery in 2018. Globally more than 2 million patients [1] have benefitted from this digital system.

This innovation achieved widespread interest and became a topic of discussion in scientific clinical research.
A literature review shows that between 2008 and 2018, the number of studies published on the topic of chest drainage systems has multiplied. In practice, it has been possible to generate new protocols which result in earlier removal of the chest drain and a reduction in the length of stay, thereby reducing hospital costs. Thanks to their evidence-based benefits, digital chest drainage systems have also been recommended in national and international guidances.


Clinical decisions are increasingly based on therapy data and economic drivers in healthcare systems. Therefore, reliable information is even more important. New ERAS® Society Guidelines aim to minimise recovery time, reduce complications, increase mobility and enable patients to become independent more quickly.

This brochure provides an overview of the development of the current research standards and guidances, that have been published since the start of digital chest drainage systems.

Enjoy reading!

1 Medela market survey

# Contents

# Digital systems are recommended

## Developments over time

**2011** Publication of the consensus paper
by ESTS, AATS, STS and GTSC to promote evidence-based management of the pleural space [1]

**2014** CADTH expert report
for compact digital chest drainage systems [2]

**2017** The Society for Translational Medicine recommends
the use of digital drainage systems in its Clinical Practice Guidelines on Postoperative Treatment of Patients after Lobectomy [3]

**2018** The new AWMF S3 guidelines calls
for use of digital drainage systems for primary/secondary pneumothorax [4]

**2018** NICE (National Institute for Health and Care Excellence) recommends
Thopaz+ for chest tube management [5]

**2018** In the European Journal of Cardio-Thoracic Surgery
a meta-analysis endorses the use of digital chest drainage systems after lung surgery [6]

**2018** The ERAS (Enhanced Recovery After Surgery) guidelines recommend
the use of digital chest drainage systems to encourage faster recovery after lung surgery [7]

**2019** In the Journal of Cardiothoracic Surgery,
another meta-analysis endorses the use of digital chest drainage systems after pulmonary resections [8]

# Overview of trial results

## Consensus paper to promote an evidence-based approach to management of the pleural space.

A collaborative proposal by ESTS, AATS, STS and GTSC[1]

### Background and concept

After thoracic surgery, the chest drain duration is a decisive factor in length of hospitalisation, costs and morbidity. However, chest drain management is often based on habit and personal experience, rather than on scientific research. For future trials, it is important to create a uniform starting point in relation to parameters and terminology, to enable the production of evidence-based guidelines and recommendations. The aim of this consensus paper was to develop a scientific framework to enable better evaluation of existing trials with a view to formulating questions, parameters and outcomes in future studies.

### Methods

The work was initiated through a partnership between the European Society of Thoracic Surgeons (ESTS), the American Association for Thoracic Surgery (AATS), the Society of Thoracic Surgeons (STS) and the General Thoracic Surgical Club (GTSC). They set various themes which would be worked on by at least two of eleven experts and then reviewed, discussed and adopted by the whole committee of experts.

### Summary of the recommendations

#### Pleural and respiratory function after lung resection

**Generation of pleural fluid and lung mechanics**

Pleural fluid is generated by the lymphatic stomata in the parietal pleura. The fluid is usually drained from the bottom of the pleural cavity and from the mediastinum. Through production and resorption, 2 to 4 ml of fluid is available per hemithorax in a healthy state. This minimal amount of fluid in the pleural cavity uses adhesive power to ensure that the lungs remain extended. In the absence of efficient lymph drainage, fluid collects in the thorax, causing the lung to collapse.

**Postoperative drainage of the pleural cavity**

Surgical interventions change the properties of the pleural space. The immediate problem is the evacuation of air from the pleural cavity. The compliance (elasticity measurement ≙ ratio of volume change to the associated change in pressure) of the lungs is reduced and is directly dependent on the resected lung volume. When attaching a chest drain, the target negative pressure generated by the system should correspond to the physiological pressure occurring. Over-extension of the lung should be avoided.

After the primary evacuation of gas/air, the body's own gas/air is slowly reabsorbed (approx. 1 % / day) and gradually replaced by pleural fluid. Due to the increased permeability of the mesothelium and/or the sub-atmospheric pressure of the drain – which encourages fluid filtration – hydrothorax may occur.

## Glossary

The following wording is recommended:

| Proposed nomenclature-definitions | Explanation | Terms not recommended |
|---|---|---|
| No external suction applied | Application of no external suction to chest drainage | Passive suction, water seal |
| External suction | Application of an external suction source to chest drainage | Suction |
| Variable suction | Suction applied by a device capable to regulate the suction level according to the preset intrapleural pressure value | Regulated suction |
| Fixed suction | Suction applied by an external source without the ability to react to intrapleural pressure variations | Unregulated suction |

**Objective air leak evaluation**

- When traditional chest drainage systems are used, air leak is assessed by detecting the formation of bubbles and forced expiratory manoeuvres or coughing. Interpretation of these can be highly subjective and it is subject to variability among observers. It becomes difficult to differentiate between a "true air leak" and the appearance of an air leak due to the air accumulated in the drain tubing
- Objective digital systems are in a position to quantify the air flow in the tubing and minimise inter-observer variability. Quantifying air leaks in ml/min instead of bubbles also offers the opportunity to depict the information in charts and tables and retrieve it as necessary. This enables standardisation of drainage management across institutions, resulting in shorter durations of chest tube drainage and lengths of hospitalisation of patients
- Due to the different technologies used in digital systems, there may be slight differences in measurement variability. Studies should be conducted in order to compare the systems
- Clinical experience in different facilities has shown that it is safe to remove the chest drain if air leakage is at < 40 ml/min with steady values or a downwards trend over the past 6–8 hours
- If studies are performed using digital systems, it is recommended that the following information be specified: air leak in ml/min, the qualitative trend over time (> 6 hours) and details of the system used

**Objective fluid drainage evaluation**

- Chest drain management and the criteria for removing a chest drain are often based on tradition and dogma rather than on data
- The "fluid production" criterion for removing the chest drain is between 200 and 450 ml / 24 h and has increasingly relaxed in recent years
- These figures appear to make sense as the estimated rate of daily physiological fluid filtration is around 350 ml / 24 h
- Further research would benefit from consistent reporting with the following information, such as:
  - Volume of drained fluid (per 24 h or per 8 h)
  - Fluid properties (e.g. bloody, chylous, etc.)
  - Type of lung resection (e.g. sublobar resection, lobectomy, etc.)
  - Patient characteristics which could contribute to pleural effusion (e.g. kidney failure, congestive heart failure, ascites, etc.)
- Definition of endpoints in future studies: it is recommended that symptomatic pleural effusion that develops within one month of the chest drain being removed be inspected and that the extent to which it is connected to onset of dyspnea be investigated

## Chest drains

**Size**

A chest drain that is 28–32 Fr in diameter is often used after a thoracotomy. However, there are not yet any unequivocal scientific data on the practical effects of the diameter in clinical cases. Catheters with a small diameter (16 Fr) are used successfully in cases of spontaneous pneumothorax or pleural effusion.

**Number**

In the literature, the use of two chest drains is often recommended (one placed in the apex of the pleural cavity and the other over the diaphragm). Studies show the same clinical results for wedge resections and lobectomies with reduced postoperative pain if only one drain is used, which is why use of one drain is recommended rather than two.

**Type**

Instead of traditional chest drains, the use of other models, such as Blake drains, is discussed repeatedly. As the medical evidence is weak, there is a need for more scientific data.

We recommend always recording the number, position, type and size of drains in future trials looking at air leak and chest tube management.

# Compact digital chest drainage systems

## For management of thoracic surgery patients: review of clinical efficacy, safety and cost effectiveness [2]

### Background and concept

Air leaks are among the most common and most costly postoperative complications after thoracic surgery. It is estimated that between 30 % and 50 % of patients develop an air leak either straight away or within the first few days after an operation. Prolonged air leaks (> 5 days) can increase the risk of infection and necessitate additional operations, which can in turn lead to longer hospitalisation and complications. With traditional water-based systems, air leaks are monitored through subjective assessment of bubbles in a water chamber. This method is prone to variability between different observers and can result in misdiagnoses.
Digital chest drainage systems continuously and objectively measure air leak flow and regulate intrapleural pressure. In this context, digital systems can offer a more reliable way to spot air leaks.

### Objective

This review was conducted by the Canadian Agency for Drugs and Technologies in Health (CADTH) to test the clinical efficacy, cost efficiency and safety of digital chest drainage systems compared to traditional drainage systems for postoperative treatment of patients who have undergone thoracic surgery.

#### Fast facts

The Canadian Agency for Drugs and Technologies in Health, CADTH for short, is an independent, not-for-profit organisation in Canada which was founded in 1989 by country's federal, provincial and territorial governments. It provides evidence, analysis, advice and recommendations to decision-makers in healthcare.

### Method

Literature review of publications from a wide range of literature databases (PubMed, The Cochrane Library, The Centre for Reviews and Dissemination (CRD), Canadian and large international healthcare technology authorities) and online that were published between January 2009 and September 2014.

The full text publications received were evaluated according to the inclusion criteria (population, intervention and control group, outcomes and study design).

### Results

A total of 7 studies (5 randomised control trials, 2 cohort trials) were included in the analysis. In summary, the use of digital chest drainage systems compared to analogue systems shows:

- reduced duration of chest tube placement
- shorter hospital length of stay
- a possible reduction in hospital costs, which is probably connected to shorter chest tube duration and shorter length of stay
- no apparent effect on postoperative or drainage-related complications

### Conclusion

This review provides an overview of the clinical efficacy, cost effectiveness and safety of digital chest drainage systems compared to traditional systems. The authors note that the evidence in this area is limited because it is not possible to design a blind trial, which creates the potential for systemic errors. Additional randomised control trials (RCTs) with detailed information on the design of the study and the methodology (e.g. criterion for drain removal, hospital costs) are required. With regard to a range of digital chest drainage systems (with different software), more comparative trials are required in order to identify possible differences between the systems.
Despite insufficient data on the use of digital chest drainage systems in surgical care, the authors see significant implications for the standardisation of chest tube management. By analysing objective data on air leak (real-time data, trends), it may, for example, be possible to develop risk models to predict prolonged air leaks.

# The Society for Translational Medicine

## Clinical practice guidelines for the postoperative management of chest drainage for patients who have had a lobectomy[3]

### Background and concept of the guidelines

In 2017, the Society for Translational Medicine published clinical practice guidelines on postoperative chest drainage for lobectomy in the Journal of Thoracic Disease. For this, the authors conducted a systematic literature review on selected topics. There is a brief summary of the trial results for each topic. Finally, recommendations reflect what is currently known and the quality of the evidence.

### Methodology

A systematic literature review was conducted in the PubMed, Scopus and ISI Web of Science databases. The literature search produced n = 56 studies, plus additional studies following expert opinions. The GRADE system was used to conduct quality assessment of the available evidence and produce the recommendations. The evidence levels are shown in the following table.

**Evidence levels:**

| Grade of recommendation | Description | Benefit versus risk | Methodology | Implications |
|---|---|---|---|---|
| 1A | Strong recommendation, high quality evidence | Benefits clearly outweigh risk | RCTs without important limitations | Apply to most patients without reservation |
| 1B | Strong recommendation, moderate quality evidence | Benefits clearly outweigh risk | RCTs with important limitations | Apply to most patients without reservation |
| 1C | Strong recommendation, low quality evidence | Benefits clearly outweigh risk | Observational studies or case series | May change with high evidence available |
| 2A | Weak recommendation, high quality evidence | Benefits closely balanced with risks | RCTs without important limitations | Best action may differ in different circumstances |
| 2B | Weak recommendation, moderate quality evidence | Benefits closely balanced with risks | RCTs with important limitations | Best action may differ in different circumstances |
| 2C | Weak recommendation, low quality evidence | Benefits closely balanced with risks | Observational studies or case series | Other alternatives may be equivalent |

## Summary of the recommendations

**Time at which chest drain removed after lobectomy**

- Chest drains can safely be removed with pleural fluid levels (non-hematic, non-chylous) of 450 ml / 24 h, which may reduce chest tube duration and hospital length of stay (2B)

**Number of chest tubes**

- One chest tube is adequate following pulmonary lobectomy (2A)

**Chest tube clearance**

- Chest tube clearance by milking and stripping offers no advantages in patients after lobectomy (2B)

**Chest tube suction following pulmonary lobectomy**

- Routine chest tube suction offers no advantage for patients undergoing lobectomy, and may only be indicated in case of progressive subcutaneous emphysema (2A)
- Regulated seal is as effective as regulated suction (–11 to –20 cm$H_2O$, depending on the type of lobectomy) when an electronic drainage system to maintain preset intrathoracic pressure is used after lobectomy by thoracotomy (2B)

**Techniques to remove chest tubes**

- There is no clear evidence indicating when during the respiratory cycle the chest tube should be removed (2A)

**Digital Chest Drainage Systems**

- Electronic drainage systems are recommended in the management of chest tube in patients undergoing elective lobectomy, as it helps reducing the clinical variability of its management (1B)

## Conclusion

In the guidelines, the authors present the current state of knowledge and recommendations regarding postoperative management of chest drains in patients who have undergone a lobectomy. In the randomised control trials, the number of participants was relatively small, which is why they recommend to test the results in larger multicenter trials. There is increasing adoption of the fast-track approach with early removal of chest tubes and a reduction in the number of chest tubes utilized following pulmonary resection. Due to their validated effectiveness, there is considerable interest in the use of digital chest drainage systems.

# S3 Guidelines

## Diagnosis and treatment of spontaneous pneumothorax and postoperative pneumothorax[4]

In March 2018, the AWMF (Association of the Scientific Medical Societies in Germany) published the new S3 guidelines "Diagnosis and treatment of spontaneous pneumothorax and postoperative pneumothorax". The guidelines were created under the leadership of the Deutsche Gesellschaft für Thoraxchirurgie (DGT – German Association of Thoracic Surgery) with input from the Deutsche Gesellschaft für Pneumologie und Beatmungsmedizin (DGP – German Association for Pneumology and Respiratory Medicine), the Deutsche Röntgengesellschaft (DRG – German X-Ray Association) and the Deutsche Gesellschaft für Innere Medizin (DGIM – German Association of Internal Medicine) and they primarily cover the diagnosis of and therapeutic treatment pathways for the symptoms of primary and secondary spontaneous pneumothorax. The next review is planned for March 2023.

### Primary spontaneous pneumothorax

**Definition**

By definition, a primary spontaneous pneumothorax occurs sponateneously in patients under 45 years old without a pre-existing lung condition and without prior thoracic intervention or injury. An x-ray of the contralateral lung is be inconspicuous.

### Secondary spontaneous pneumothorax

**Definition**

A secondary spontaneous pneumothorax is indicated when the patient's medical history includes a lung condition, they report pulmonary symptoms prior to the event, the x-ray shows a pathological lung structure on the side which has not been affected, or the patient is 45 or older.

### Recommendations on chest drain management[1]

- If the pneumothorax requires treatment, aspiration or use of a small-diameter chest drain (≤ 14 Fr) is recommended as the primary treatment (recommendation level A, evidence level 1, consensus strength 93 %)
- Indication for use of a chest drain with suction: symptomatic pneumothoraces with major lung collapse, prolonged air leak (> 48 hours with drain present) with or without incomplete re-expansion of the lung
- Chest drainage on suction helps to produce and maintain negative pressure in the pleural cavity. Optimum negative pressure between –10 to –20 $cmH_2O$ is accepted
- Routine continuation of suction after re-expansion is not recommended (recommendation level A, evidence level 1, consensus strength 93 %)
- Digital chest drainage systems are part of modern chest drain management. They ensure continuous measurement and objective recording of air leaks. This is associated with a reduction in chest drain duration, length of hospital stay and duration of treatment
- Where chest drain use is indicated, a small-diameter drain (≤ 14 Fr) is recommended as it is less painful for patients, reduces the potential for infection and bleeding and is associated with shorter length of stay (recommendation level A, evidence level 2, consensus strength 100 %)
- Patients with high-output fistulas may be an exception to this
- Routine continuation of suction after re-expansion is not recommended (recommendation level A, evidence level 1, consensus strength 100 %)
- Digital chest drainage systems are part of modern chest drainage management. They ensure continuous measurement and objective recording of air leaks

### Fast facts

**Recommendation level:** binary choice of recommendation in A: "we recommend/we do not recommend", B: "we suggest/we do not suggest"
**Evidence level:** 1–5 according to the Oxford Centre for Evidence-Based Medicine; where evidence is lacking: expert consensus
**Consensus strength:** provided as a percentage

1 You can find all other recommendations in the S3 guidelines: Diagnosis and treatment of spontaneous pneumothorax and postoperative pneumothorax

# NICE recommends

## the portable digital system Thopaz+ for managing chest drains [5]

In March 2018, the British National Institute for Health and Care Excellence (NICE) released a guidance recommending the use of digital chest drainage system Thopaz+ for people who need chest drainage after pulmonary resection or because of a pneumothorax.

### Methodology

The recommendations are based on the results of a systematic literature review. A total of 13 studies with 1,632 subjects from Europe, Asia and the USA were included. Of these, 6 studies (n = 826 patients) were RCTs. Eleven studies analysed the use of Thopaz+ after lung resection, two analysed its use after a pneumothorax.

### Results

NICE recommends using Thopaz+ for chest drainage because

- Cost modelling at a national level indicates a saving compared with conventional systems, primarily due to reduced length of stay:
  - Saving after pulmonary resection: ~£110
  - Saving after pneumothorax: ~£550
- Calculations suggest the potential for annual savings of around £8.5 million in England
- Drainage time and length of stay are reduced
- Patient safety increases
- The clinical experts explained that using Thopaz+ allows treatment across wards to be standardised
- Clinical decision making is improved through continuous, objective monitoring of air leaks and fluid loss
- Patient mobility increases, which in turn has a positive impact on patient satisfaction and recovery

### Fast facts

NICE is an executive non-departmental public body of the Department of Health in England, which publishes guidelines in various health and social care fields. Independent committees composed of experts and representatives of the public assess the clinical effectiveness and economic efficiency of healthcare technologies using up-to-date published literature.


Calculations are based on local cost data, in this case from the United Kingdom

# Digital chest drainage is better

## than traditional chest drainage following pulmonary surgery: a meta-analysis[6]

### Background and concept of the trial

In March 2018, Zhou and colleagues published a systematic literature review and meta-analysis in the European Journal of Cardio-Thoracic Surgery. For the first time, primary data from randomised control trials were collated in a meta-analysis and the data on digital and traditional chest drainage systems following pulmonary surgery were investigated with regard to postoperative endpoints (duration of chest tube placement, length of hospital stay, air leak duration, postoperative costs, occurrence of prolonged air leak (PAL) and percentage of patients discharged on a device.). Until 31 July 2017, two researchers independently conducted a search using the databases PubMed, EMBASE and Web of Science databases to identify eligible studies.

A total of 10 randomised control trials, carried out between 2008 and 2017, were included in the evaluation. They covered a total of 1,268 patients (642 digital, 626 analogue) and had the following characteristics:

- Sample size: ranging from 31 to 381 participants per study
- Age: between 17 and 70 years old
- Operation: pulmonary surgery for lung cancer, spontaneous pneumothorax or other lung diseases (primarily lobectomy, wedge resection, segmentectomy)
- Digital systems: Thopaz® (Medela), Drentech® (REDAX), Digivent® (Millicore AB)
- Traditional chest drainage systems: Pleur-evac A-6002-08 (Teleflex Inc.), Thora-Seal® (Covidien)
- Criterion for removing the drain: no air leak (threshold value varies between trials) or no abnormal findings on a chest radiograph (sufficient lung expansion was shown)

### Results

The meta-analysis showed that, where digital chest drainage systems were used after lung surgery in comparison to analogue systems,

- Duration of chest tube placement was 0.72 days (≙ 17.3 hours) shorter, a significant reduction (10 studies: digital n = 642, traditional chest drainage system n = 626; 95 % confidence interval (CI) –1.03 to –0.40; p < 0.001)
- Length of hospital stay was significantly reduced by nearly a day (–0.97 days ≙ 23.3 hours) (9 studies: digital n = 612, traditional n = 597; 95 % CI –1.46 to –0.48; p < 0.001)

  Sub-group analysis with lung resection: significant reduction of 0.87 days ( ≙ 20.9 hours) (95 % KI –1,37 to –0,36; p < 0,001)
- The air leak duration was reduced significantly by nearly a day (–0.95 days ≙ 22.8 hours) (3 studies: digital n = 316, traditional n = 309; 95 % CI –1.51 to –0.39; p < 0.001)
- There were no significant differences regarding the occurrence of prolonged air leak (> 5 days) (3 studies: RR1 0.36; 95 % CI 0.04 to 3.17; p = 0.36)
- Postoperative costs were reduced by an average of €443.16 (2 studies: 95 % CI –747.60 to –138.73; p = 0.004)
- There was no significant difference in the number of patients discharged home with a chest drain (3 studies: RR 0.67; 95 % CI 0.25 to 1.79; p = 0.43)
- There was no significant difference in the occurrence of postoperative air leak on days 1, 2 or 3 (2 studies, day 1: RR 1.17; 95 % CI 0.86 to 1.58; p = 0.32) (2 studies, day 2: RR 1.15; 95 % CI 0.68 to 1.95; p = 0.61) (2 studies, day 3: RR 1.20; 95 % CI 0.54 to 2.65; p = 0.65

### Conclusion

Digital drainage systems have several benefits over traditional systems:

1. They allow continuous recording of air leaks.
2. Digital devices decrease the variability caused by physician judgments regarding when a chest tube should be removed.
3. Digital chest drains provide precise, stable negative pressure without the influence of position changes or obstruction of tubes.
4. Digital devices maintain a stable intrathoracic pressure more effectively.
5. Digital drainage systems, especially the Thopaz, are portable and quiet.

1 Relative risk


MEDIA
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# Guidelines for enhanced recovery after lung surgery

## Recommendations of the Enhanced Recovery After Surgery (ERAS®) Society and the European Society of Thoracic Surgeons (ESTS)[7]

### Background and concept of the guidelines

Standardised perioperative care helps to ensure that patients receive optimal treatment. These evidence-based perioperative care protocols are already established in some fields, like colorectal surgery. In this area it was possible to show that ERAS had a positive impact on

- Reduction of length of stay and
- Reduction of complications by
  - attenuating the homeostatic disturbance and stress response
  - diminishing postoperative organ dysfunction
  - facilitating recovery

The goal of these guidelines is to make recommendations for elements of perioperative care in lung surgery. Recommendations were developed for 45 ERAS items, from initial presentation through to postoperative discharge.

### Question

What does optimal perioperative management for thoracic surgery patients look like to reduce postoperative disruption in organ function and accelerate healing. This should be achieved through the introduction of various evidence-based perioperative measures.

### Method

For each perioperative measure (module element) the literature databases Medline and PubMed were trawled to identify meta-analyses, systematic reviews, randomized controlled studies, non-randomized controlled studies, reviews and case series which were published between 1966 and 2017. Smaller prospective and retrospective cohort trials were also considered where no higher-quality evidence was available. The quality of evidence and recommendations were evaluated according to the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) system. A strong or weak recommendation was given depending on the quality of the evidence and the balance of desirable to undesirable effects with various treatment options.

### Summary of the results

Recommendations were developed for a total of 45 enhanced recovery items covering topics related to preadmission, admission, intraoperative care and postoperative care. The module elements, split into the four phases, are summarised on the next page.

| Module elements | Evidence level | Recommendation grade |
|---|---|---|
| **Preoperative phase** | | |
| Preadmission information, education and counselling | Low | Strong |
| Patients should be screened preoperatively for nutritional status and weight loss | High | Strong |
| Oral nutritional supplements should be given to malnourished patients | Moderate | Strong |
| Immune-enhancing nutrition may have a role in the malnourished patient postoperatively | Low | Weak |
| Smoking should be stopped at least 4 weeks before surgery | High | Strong |
| Alcohol consumption (in alcohol abusers) should be avoided for at least 4 weeks before surgery | Moderate | Strong |
| Anaemia should be identified, investigated and corrected preoperatively | High | Strong |
| Prehabilitation should be considered for patients with borderline lung function or exercise capacity | Low | Strong |
| **Admission** | | |
| Clear fluids should be allowed up until 2 h before the induction of anaesthesia and solids until 6 h before induction of anaesthesia | High | Strong |
| Oral carbohydrate loading reduces postoperative insulin resistance and should be used routinely | Low | Strong |
| Routine administration of sedatives to reduce anxiety preoperatively should be avoided | Moderate | Strong |
| **Perioperative phase** | | |
| Patients undergoing major lung resection should be treated with pharmacological and mechanical VTE prophylaxis | Moderate | Strong |
| Patients at high risk of VTE may be considered for extended prophylaxis with LMWH for up to 4 weeks | Low | Weak |
| Routine intravenous antibiotics should be administered within 60 min of, but prior to, the skin incision | High | Strong |
| Hair clipping is recommended if hair removal is required | High | Strong |
| Chlorhexidine-alcohol is preferred to povidone-iodine solution for skin preparation | High | Strong |
| Maintenance of normothermia with convective active warming devices should be used perioperatively | High | Strong |
| Continuous measurement of core temperature for efficacy and compliance is recommended | High | Strong |
| Lung-protective strategies should be used during one-lung ventilation | Moderate | Strong |
| A combination of regional and general anaesthetic techniques should be used | Low | Strong |
| Short-acting volatile or intravenous anaesthetics, or their combination, are equivalent choices | Low | Strong |
| Non-pharmacological measures to decrease the baseline risk of PONV should be used in all patients | High | Strong |
| A multimodal pharmacological approach for PONV prophylaxis is indicated in patients at moderate risk or high risk | Moderate | Strong |

| Module elements | Evidence level | Recommendation grade |
|---|---|---|
| **Perioperative phase** | | |
| Regional anaesthesia is recommended with the aim of reducing postoperative opioid use. Paravertebral blockade provides equivalent analgesia to epidural anaesthesia | High | Strong |
| A combination of acetaminophen and NSAIDs should be administered regularly to all patients unless contraindications exist | High | Strong |
| Ketamine should be considered for patients with pre-existing chronic pain | Moderate | Strong |
| Dexamethasone may be administered to prevent PONV and reduce pain | Low | Strong |
| Very restrictive or liberal fluid regimes should be avoided in favour of euvolemia | Moderate | Strong |
| Balanced crystalloids are the intravenous fluid of choice and are preferred to 0.9 % saline | High | Strong |
| Intravenous fluids should be discontinued as soon as possible and replaced with oral fluids and diet | Moderate | Strong |
| Patients taking b-blockers preoperatively should continue to take them in the postoperative period | High | Strong |
| Magnesium supplementation may be considered in magnesium deplete patients | Low | Weak |
| It is reasonable to administer diltiazem preoperatively or amiodarone postoperatively for patients at risk | Moderate | Weak |
| If a thoracotomy is required, a muscle-sparing technique should be performed | Moderate | Strong |
| Intercostal muscle- and nerve-sparing techniques are recommended | Moderate | Strong |
| Reapproximation of the ribs during thoracotomy closure should spare the inferior intercostal nerve | Moderate | Strong |
| A VATS approach for lung resection is recommended for early-stage lung cancer | High | Strong |
| **Postoperative phase** | | |
| The routine application of external suction should be avoided | Low | Strong |
| Digital drainage systems reduce variability in decision-making and should be used | Low | Strong |
| Chest tubes should be removed even if the daily serous effusion is of high volume (up to 450 ml/24 h) | Moderate | Strong |
| A single tube should be used instead of 2 after anatomical lung resection | Moderate | Strong |
| In patients with normal preoperative renal function, a transurethral catheter should not be routinely placed for the sole purpose of monitoring urine output | Moderate | Strong |
| It is reasonable to place a transurethral catheter in patients with thoracic epidural anaesthesia | Low | Strong |
| Patients should be mobilized within 24 h of surgery | Low | Strong |
| Prophylactic minitracheostomy use may be considered in certain high-risk patients | Low | Weak |

## Recommendations on chest drain management

Management of chest tubes remains a critical aspect in the postoperative course of patients following lung resection, influencing the recovery phase and hospital stay. Although a drain is necessary for the majority of cases, they can cause pain, reduced pulmonary function and immobility, irrespective of the surgical approach.

**Suction vs. no suction**

The question of whether external suction or its absence has a beneficial effect on clinical outcomes has been the subject of several systematic reviews and clinical guidelines. Although the evidence is conflicting, there does not appear to be an advantage to the routine application of external suction in terms of shortening the duration of air leak, chest drainage or LOS.

**Digital Chest Drainage Systems**

Digital drainage systems have several advantages over a traditional water seal.

**The following advantages of the system are cited:**

- Objective quantification of the volume of air leak. The ability to store information and display trends in air leak over time allows more informed decision-making about chest tube removal and reduces interobserver and clinical practice variability
- They are light, compact and have a built-in suction pump, so do not need to be attached to wall suction, should suction be required, favouring early patient mobilization
- A multicentre randomized trial showed that their use reduced the duration of chest tube duration by 1.1 days and the length of hospital stay by 1 day after lobectomy
- Higher levels of patient satisfaction paralleled the objective clinical benefits

**Drainage of fluid**

Pleural fluid turnover is regulated by Starling forces and by the lymphatic drainage system located at the parietal level. The hourly turnover of the pleural fluid is approximately 0.2 ml/kg leading, in physiological conditions, to its complete renewal in approximately 1 h. Lymphatics act as an efficient negative feedback system to regulate pleural fluid dynamics as they can markedly increase flow (20–30-fold) in response to increased filtration, as occurs after thoracic surgery due to postoperative inflammation. Studies on more aggressive chest drain removal strategies within fast track programmes have been shown to be safe. A non-chylous fluid threshold of 450 ml/day after thoracotomy was associated with only a 0.55 % readmission rate for recurrent symptomatic pleural effusion. A higher threshold of 500 ml/day following VATS lobectomy resulted in an incidence of clinically relevant recurrent effusions in only 2.8 % of patients.

**Note**

Against a background of electronically-controlled drainage systems in particular, this issue is somewhat dated as these digital devices offer the benefit that they only generate intrapleural suction when the pre-set negative pressure (target value) deviates from the value recorded (actual value).

**Number of chest tubes**

Traditionally, thoracic surgeons have used 2 chest tubes to drain the pleural space after lobectomy. Several randomized trials have demonstrated that the use of a single chest tube after lobectomy is safe and effective with no differences in residual pleural effusion or the need to reinsert a chest tube but is significantly less painful than 2 drains. Furthermore, a single drain is associated with a reduced duration of chest drainage and a smaller volume of fluid drained.

## Conclusion

The use of a systematic ERAS pathway has the potential to improve outcomes after thoracic surgery.

# Digital chest drainage system versus traditional chest drainage system after pulmonary resection

## Systematic review and meta-analysis [8]

### Background and concept of the trial

In January 2019, a systematic literature review and meta-analysis was published in the Journal of Cardio-thoracic Surgery. It analysed primary data from studies which compared the use of digital and traditional chest drainage systems after pulmonary resection (including lobectomy, segment resection and wedge resection). The endpoints of the meta-analysis were prolonged air leak (> 5 days), duration of chest drainage and length of hospital stay.

The analysis included studies up to January 2018 from the databases Web of Science and PubMed, which were selected by two independent reviewers. The research produced eight studies (3 observational studies and 5 RCTs) with a total of 1,487 patients (720 digital, 767 traditional) which were published between 2009 and 2017.

### Results

The meta-analysis showed that, where digital chest drainage systems are used after pulmonary resection in comparison to traditional chest drainage systems:

- Significant reduction of the risk of prolonged air leak (> 5 days) compared with traditional chest drainage system
  (5 studies: RR1 0.54; 95 % CI 0.40 to 0.73; $p < 0.0001$)
- Significant reduction of the duration of chest drainage compared with traditional chest drainage system
  (2 studies: SMD = –0.35; 95 % CI –0.60 to –0.09; $p = 0.008$)
- Significant reduction of the length of hospital stay compared with traditional chest drainage system
  (2 studies: SMD = –0.35; 95 % CI –0.61 to –0.09; $p = 0.007$)

### Conclusion

The present systematic review shows that digital chest drainage system is expected to benefit patients to attain faster recovery and higher life quality as well as to reduce the risk of postoperative complications.
Further RCTs with larger sample size are still needed to more clearly elucidate the advantages of digital chest drainage system.

1 Relative risk
2 Standardised mean difference

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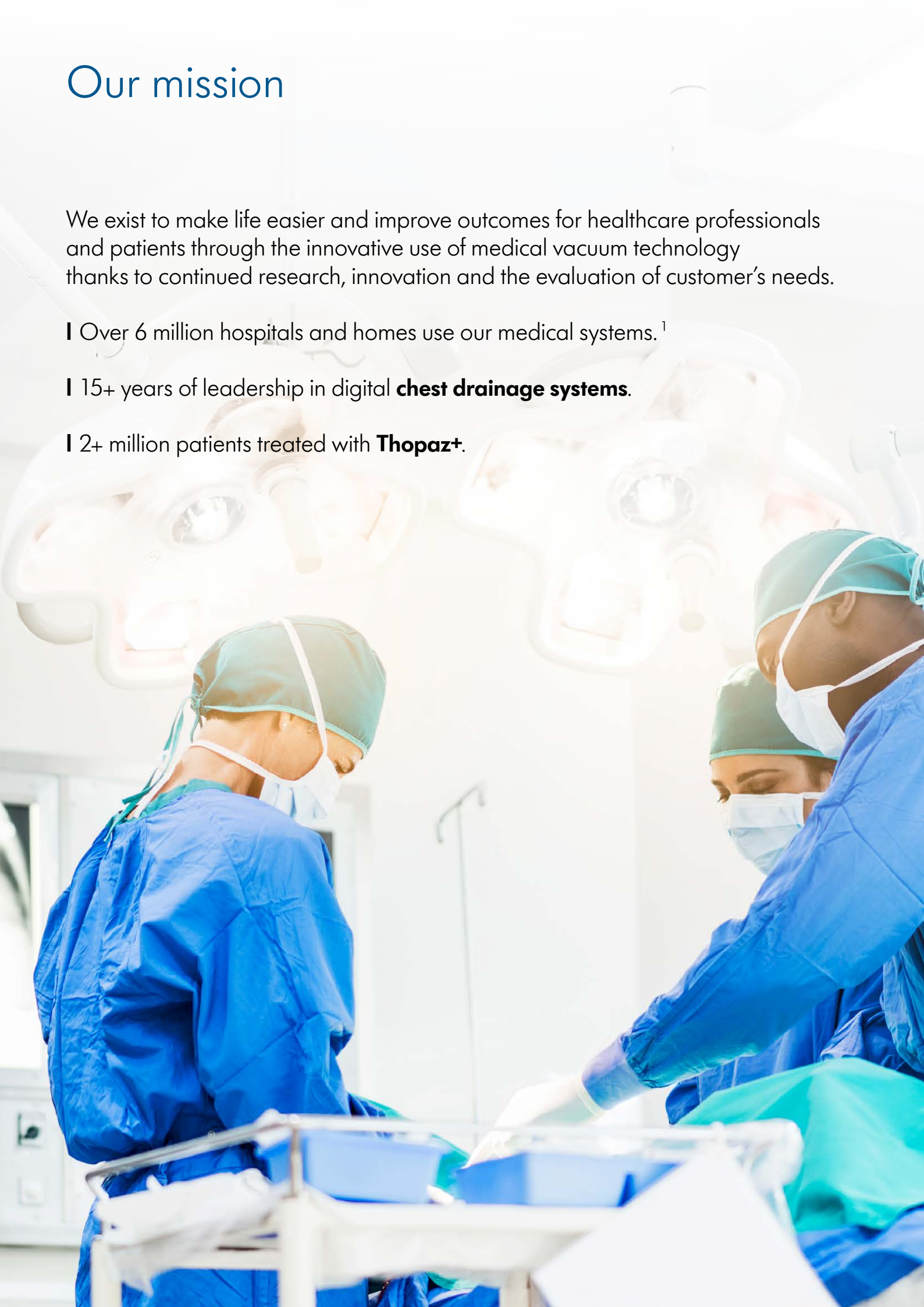

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