From the Department of Neurobiology, Care Sciences and Society
Karolinska Institutet, Stockholm, Sweden

# MOBILIZATION IMMEDIATELY AFTER ELECTIVE ABDOMINAL SURGERY

## - Respiratory effects and patients´ and healthcare professionals´ experiences

Anna Svensson-Raskh

Stockholm 2021

All previously published papers were reproduced with permission from the publisher.
Published by Karolinska Institutet.
Printed by Universitetsservice US-AB, 2021

ISBN 978-91-8016-233-3

# MOBILIZATION IMMEDIATELY AFTER ELECTIVE ABDOMINAL SURGERY

## – Respiratory effects and patients´ and healthcare professionals´ experiences

THESIS FOR DOCTORAL DEGREE (Ph.D)

By

**Anna Svensson-Raskh**


*Principal Supervisor:*
Associate Professor Malin Nygren-Bonnier
Karolinska Institutet
Department of Neurobiology, Care Sciences and Society
Division of Physiotherapy

*Co-supervisors:*
Professor Monika Fagevik Olsén
Gothenburg University
Department of Neuroscience and Physiology
Division of Health and Rehabilitation

Associate Professor Anna Schandl
Karolinska Institutet
Department of Molecular Medicine and Surgery
Division of Surgical Care Science

Professor Emerita Agneta Ståhle
Karolinska Institutet
Department of Neurobiology, Care Sciences and Society
Division of Physiotherapy

*Opponent:*
PhD Charlotte Urell
Uppsala University
Department of Neuroscience,
Physiotherapy

*Examination Board:*
Associate Professor Anette Forsberg
Örebro University
Department of Medicine and Health
Division of Physiotherapy

Associate Professor Folke Hammarqvist
Karolinska Institutet
Department of Clinical Science,
Intervention and Technology
Division of Surgery

Professor Åsa Engström
Luleå University of Technology
Department of Health, Education and
Technology
Division of Nursing and Medical
Technology


AKADEMISK AVHANDLING
som för avläggande av medicine doktorsexamen vid Karolinska Institutet offentligen försvaras i hörsal 4V, Alfred Nobels allé 8, Huddinge, fredagen den 18 juni kl. 09:00

**Illustration**: A lady mobilized to sitting in a chair within 2 hours after arrival at the postoperative recovery unit after abdominal surgery. By Kristina Kindblom 2021

> ***There are things known and there are things unknown, and in between are the doors of perception.***
>
> ***Aldous Huxley***

> ***We see the world as 'we' are, not as 'it' is; because it is the "I" behind the 'eye' that does the seeing.***
>
> ***Anais Nin***

# ABSTRACT

To prevent postoperative complications after abdominal surgery, mobilization is highly recommended and suggested to start as soon as possible. However, few studies have investigated the respiratory effects of immediate postoperative mobilization among patients undergoing elective open or robot-assisted laparoscopic abdominal surgery. Nor have patients´ and healthcare professionals´ experiences of such an early mobilization procedure been investigated.

Participants in study I to III were recruited from an out-patient pre-anesthesia clinic at Karolinska University Hospital Solna, Stockholm. For paper IV, the participants were recruited from the postoperative recovery unit at the same hospital. **Paper I** was a 3-armed RCT, consecutively including 214 patients who underwent elective open or robot-assisted laparoscopic gynecological, urological, or endocrinological abdominal surgery with an anesthetic duration of >2 hours. Patients were randomized to mobilization only (to sit in a chair) (n = 76), mobilization (to sit in a chair) in combination with breathing exercises (n = 73), or to be controls (no treatment) (n = 65). The interventions started within 2 hours after arrival at the postoperative recovery unit. The results showed that compared with the controls, $SpO_2$ and $PaO_2$ improved for patients in the intervention groups. **Paper II** was a secondary analysis of data from the RCT including the patients who were assigned to and complied with the mobilization interventions (n = 137). Mobilization initiation time and duration of mobilization were investigated in relation to $SpO_2$ and $PaO_2$. The results indicated that mobilization within the first hour after surgery was not superior to being mobilized within the second hour regarding $SpO_2$ and $PaO_2$. Further, $SpO_2$ and $PaO_2$ were similar between the groups irrespective of whether the patients were mobilized for less than 30 minutes, between 30 and 90 minutes, or longer than 90 minutes. **Paper III** included face-to-face interviews with 23 patients who were randomized to one of the mobilization interventions. The overarching theme that emerged from the content analysis was “To do whatever it takes to get home earlier”, which was built on the three categories; “The impact of mobilization”, “To feel safe and be confident with the mobilization process”, and “Experiences and motivational factors”. **Paper IV**, was an interview study of 17 healthcare professionals who had been involved in mobilization of patients in the RCT. The interviews were analyzed with content analysis and resulted in the overarching theme “A changed mindset” which represented a turning point when the healthcare professionals observed that mobilization was safe and beneficial for the patients, and their safety concerns were reduced.

The overall conclusion of this thesis was that mobilization immediately after abdominal surgery improved $SpO_2$ and $PaO_2$. Initiation time and duration of mobilization seemed to be of less importance. Patients found that it improved their physical and mental well-being. The healthcare professionals ‘experienced the postoperative recovery unit was a safe place for initiating mobilization as long as they had access to sufficient resources and a well-functioning multiprofessional team of nurses, assistant nurses and physiotherapists.

# SAMMANFATTNING

Patienter som genomgått bukkirurgi rekommenderas att mobiliseras så tidigt som möjligt eftersom det anses förebygga risken för postoperativa komplikationer. Få studier har dock undersökt de respiratoriska effekterna av omedelbar postoperativ mobilisering för patienter som genomgått elektiv öppen eller robot-assisterad laparoskopisk bukkirurgi. Inte heller har patienter eller vårdgivares erfarenheter av en så tidig mobiliseringsprocedur undersökts.

Deltagarna i studie I till III rekryterades på pre-anestesikliniken och deltagarna till studie IV rekryterades på den postoperativa vårdavdelningen vid Karolinska universitetssjukhuset Solna, Stockholm. **Studie I** var en 3-armad RCT, där 214 patienter som genomgått elektiv öppen eller robotassisterad laparoskopisk gynekologisk, urologisk eller endokrinologisk bukkirurgi, med en anestesitid > 2 timmar konsekutivt inkluderades. Patienterna randomiserades till mobilisering (att sitta i en fåtölj) (n = 76), till mobilisering (att sitta i en fåtölj) och andningsgymnastik (n = 73), eller till kontrollgruppen (ingen intervention) (n = 65). Interventionerna startade inom två timmar efter ankomst till den postoperativa vårdavdelningen. Patienterna i interventionsgrupperna förbättrades i $SpO_2$ och $PaO_2$, inga sådana förbättringar noterades för kontrollgruppen. **Studie II** var en sekundär analys av data från RCTn och inkluderade patienter som randomiserats till och fullföljt endera av de två mobiliseringsinterventionerna (n=137). Mobiliseringsstart och varaktighet av mobiliseringen undersöktes i förhållande till utfall i $SpO_2$ och $PaO_2$. Studien indikerade att mobilisering inom en timme efter kirurgi inte var bättre för utfall i $SpO_2$ och $PaO_2$ jämfört med om mobiliseringen startade inom den andra timmen efter kirurgi. Det förelåg inte heller några skillnader gällande utfall i $SpO_2$ och $PaO_2$ för patienter som mobiliserades kortare än 30 minuter, mellan 30 och 90 minuter eller över 90 minuter. **Studie III** var en kvalitativ studie där enskilda intervjuer genomfördes på ett urval patienter (n = 23) som erhållit någon av mobiliseringsinterventionerna i RCTn. Det övergripande temat som framkom ur innehållsanalysen var ”Att göra vad som krävs för att komma hem tidigare”, vilket baserades på kategorierna; Effekten av mobilisering, Att känna sig trygg och säker med mobiliseringsprocessen och Erfarenheter och motiverande faktorer. **Studie IV** var en intervjustudie av 17 vårdgivare som varit involverade i mobilisering av patienter i RCTn. Intervjuerna analyserades med innehållsanalys och resulterade i ett övergripande tema ”En förändrad inställning” vilket representerar en vändpunkt då vårdpersonalens oro reducerades när de noterade att mobiliseringen var såväl säker som välgörande för patienterna.

Den övergripande slutsatsen av denna avhandling är att mobilisering omedelbart efter bukkirurgi förbättrade $SpO_2$ och $PaO_2$. Mobiliseringsstart och total mobiliseringstid verkade vara av mindre betydelse. Patienterna angav att mobiliseringen förbättrade deras mentala och fysiska välbefinnande. Vårdgivarna upplevde att den postoperativa vårdavdelningen fungerade väl vid den initiala mobiliseringen förutsatt tillgång till nödvändiga resurser för genomförande, samt att det multiprofessionella teamet bestående av sjuksköterskor, undersköterskor och fysioterapeuter finns på plats.

# LIST OF SCIENTIFIC PAPERS

The thesis encompasses the following four papers that referred to in the text by their Roman numerals.

I. Svensson-Raskh A, Schandl A, Ståhle A, Nygren-Bonnier M, Fagevik Olsén M.
Mobilization started within 2 hours after abdominal surgery improves peripheral and arterial oxygenation: A single-center randomized controlled trial. *Physical Therapy*. 2021; 101:1-11. doi: 10.1093/ptj/pzab094.

II. Svensson-Raskh A, Fagevik Olsén M, Hagströmer M, Schandl A, Nygren-Bonnier M.
Time point being mobilized, duration of mobilization and respiratory function after abdominal surgery. In manuscript

III. Svensson-Raskh A, Schandl A, Holdar U, Fagevik Olsén M, Nygren-Bonnier M.
”I have everything to win and nothing to lose”: Patient experiences of mobilization out of bed immediately after abdominal surgery. *Physical Therapy*. 2020; 100(12):2079-2089.

IV. Svensson-Raskh A, Fagevik Olsén M, Nygren-Bonnier M, Schandl, A.
Healthcare professionals´ experiences of mobilization within 2 hours after abdominal surgery: a qualitative study. Submitted manuscript.

# CONTENTS

# LIST OF ABBREVIATIONS

| | |
|---|---|
| CI | Confidence Interval |
| ERAS | Enhanced Recovery After Surgery |
| $FEV_1$ | Forced Expiratory Volume in 1 second |
| FRC | Functional Residual Capacity |
| $FEV_1$/FVC | Forced Expiratory Volume in 1 second/Forced Vital Capacity |
| FVC | Forced Vital Capacity |
| MD | Mean Differences |
| OR | Odds Ratio |
| PEEP | Positive End Expiratory Pressure |
| PEF | Peak Expiratory Flow |
| PPC | Postoperative Pulmonary Complications |
| RCT | Randomized Controlled Trial |
| SD | Standard Deviation |

# 1 INTRODUCTION

Bedrest after abdominal surgery is associated with an increased risk of postoperative complications, including deep vein thrombosis, loss of muscle mass, fatigue, atelectasis, and pneumonia (1-5). These complications are associated with an increased length of hospital stay and a need for rehabilitation to be able to independently perform activities of daily life (3, 6). Consequently, there is a prolonged time before returning to work, or to life as it was prior to the surgery (3), and thus complications have significant consequences for the individual and for society as a whole.

Mobilization out of bed – to sit or stand – is considered to counteract these complications and is therefore highly recommended (1, 2, 7-12). Despite these recommendations, there has been little focus on the use and the effect of mobilization out of bed as an intervention already in the immediate postoperative phase in the postoperative recovery unit.

For the patient who undergoes elective abdominal surgery, a process of mental and physical preparation starts from diagnosis, and moves towards planning for surgery, the operation itself, the postoperative care, and moving into the ward with the hope of a quick recovery and quick return home. During these steps, the patient and the healthcare professionals are key figures, not least in the immediate postoperative stage. Every step of the way after surgery is important, even the immediate postoperative care, because recovery and rehabilitation start already at this stage. More effort is needed to identify factors that facilitate the patient's recovery starting already at the postoperative recovery unit.

# 2 BACKGROUND

## 2.1 Abdominal surgery

In 2019, approximately 760,000 surgical procedures on adults were performed in Sweden, and about 30% of them were elective abdominal, urological, gynaecological, or endocrinological surgeries. Many of these surgeries were performed because of malign or benign tumours (13). Elective surgery is predominantly scheduled for daytime, Monday to Friday, thus the patients enter the postoperative recovery unit in the afternoon or evening depending on the commencement and duration of surgery.

Elective surgery in the abdominal cavity can be performed using diverse techniques. Minimally invasive surgery, such as robot-assisted laparoscopic techniques, are preferred to open surgery where applicable, for example, in radical prostatectomy (urology) and various gynecological procedures (14, 15). The robot-assisted technique offers three-dimensional visualization and joints that can rotate 360º (15). Even though robot-assisted surgery might reduce the actual knife time and total length of stay at postoperative recovery unit and hospital, it involves, as do all types of surgery, a stress on the body with a risk for postoperative hemodynamical changes, pain, nausea, thromboembolism, and surgical and pulmonary infections (14, 16, 17). Moreover, it has been argued that the robot is excessively expensive, the learning curve for the surgeons is too steep, and the preparation of the equipment and the patient pre-surgery is too long, and thus the duration of the surgery and anesthesia is for some surgeries prolonged compared to laparoscopic or open techniques (14-16, 18).

## 2.2 Abdominal surgery and the impact on respiratory function

During open abdominal surgery, the patient is mainly posed in a supine position, a position that enables the relaxed abdomen to press against the diaphragm. The pressure against the diaphragm adversely affects its ability to contract, thus resulting in lower inspiratory volumes with reduced functional residual capacity (FRC, the lung volume at the end of a normal expiration) and closure of small airways and atelectasis (19, 20). Dureuil et al. found that the FRC and the FVC were reduced for three days after lower abdominal surgery, though this was in a small cohort of patients in the 1970s and surgery and anesthesia have been refined since then (19).

During robot-assisted laparoscopic urological and gynecological surgery, the patient is initially posed in supine position, then tilted in a Trendelenburg position (head down) for a period of time and the abdomen is inflated with carbon dioxide. Movements of the patient are made to improve the visibility for the surgeon (14, 21). At the end of surgery, the gas is removed, and any remaining gas is slowly absorbed by the tissues. The perioperative pressure of the gas in the abdomen in combination with having been in the Trendelenburg position can lead to pain in the shoulders and abdomen after awakening, which may make it difficult for the patient to breathe deeply and to cough (14, 21). Moreover, some patients have difficulties ventilating the carbon dioxide, with increased levels remaining at the end of anesthesia and in the initial postoperative period after surgery, which may cause drowsiness (21).

The Trendelenburg position and the supine position during surgery might in robot-assisted laparoscopic as well as in open surgery cause reduced FRC, atelectasis, and disrupted gas exchange due to the same physiological causes described above even though a positive end expiratory pressure (PEEP) is applied during the mechanical ventilation (19, 22-26).

### 2.3 General anesthesia during abdominal surgery and the impact on respiratory function

Several factors influence patients´ lung function during anesthesia. It is well known that FRC decreases in the supine position (22), and the addition of anesthesia causes a further reduction of approximately 0.4–0.5 liters irrespective of whether the patient is on mechanical ventilation or breathing spontaneously (27, 28). When anesthesia, surgery, and a supine position are combined, the FRC may decrease up to 1.5 liters, with a considerable individual variation (27, 29). The mechanisms behind the reduction in FRC during general anesthesia are not yet fully understood, but they are likely to be based on a combination of factors:

- Position: supine, Trendelenburg, prone (22, 23, 30)
- Muscle relaxation: diaphragm, intercostal muscles, spinal muscles, loss of muscle tone in the airways (29, 31-33)
- Changes in spinal curvature and ribcage (23, 34, 35)
- Reduced lung volumes (22, 34-36)
- Decrease in lung compliance (22, 23, 34-36)

All of these result in decreased FRC towards closing capacity and closure of the small airways, thus carrying a risk of developing atelectasis (22, 34, 35), as shown in figure 1. A previously published study found that the use of muscle relaxants (neuromuscular blockers) during surgery was associated with an increased risk for postoperative pulmonary complications (PPC) such as respiratory insufficiency, atelectasis, and pneumonia (37).

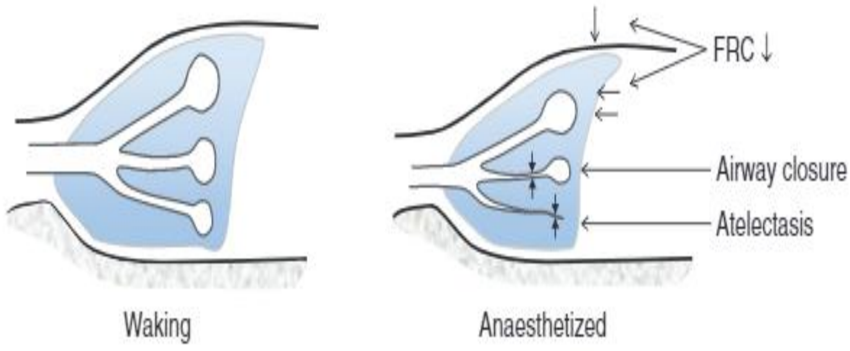


**Figure 1**, showing the distal airways in an awake and anesthetized patient and the impact on FRC, airway closure, and formation of atelectasis. From Hedenstierna et al. (38) reprinted with permission from the publisher.

Nearly all patients develop atelectasis and collapsed lung tissue already at induction of anesthesia, and this is visible by computer tomography for hours up to days after anesthesia (33, 39, 40). Lindberg et al. found that in patients undergoing lower abdominal surgery the atelectatic area was the greatest at the second hour after surgery and remained more or less the same for 2 days postoperatively (41).

During anesthesia, the ability to cough is eliminated and the produced secretions remain in the airways, which also increases the risk of airway closure. After surgery and anesthesia, pain from the wound might reduce the ability to cough, to take deep breaths, and to mobilize, thus decreasing the inspiratory volume and the ability to eliminate secretions (3, 42). The accumulated risk of impaired respiratory function and PPC after general anesthesia and surgery is therefore considerable (33, 41, 43, 44).

### 2.4 Postoperative pulmonary complications

PPC is an umbrella term encompassing diverse pulmonary complications appearing after surgery (33) that are associated with an increased length of hospital stay and rehabilitation (3, 45). The incidence of PPC after surgery is reported to be 1–40% depending on the definition of PPC and the type of surgery (45-50). Unfortunately, there has been a lack of consensus in regards of how to define postoperative pulmonary complications, thus making it difficult to estimate the risk of PPC. The European Perioperative Clinical Outcome joint task force (EPCO) made an attempt to define PPC and included the following factors in the definition: respiratory infection, respiratory failure, pleural effusion, atelectasis, and pneumothorax (51). A uniform definition is paramount to understanding and addressing the factors that can lead to an increased risk of PPC. Research has also focused on risk prediction scales; however, the applicability and precision of these scales vary because they are based on different definitions of PPC and different cohorts (49, 52-54). In a systematic review on nonthoracic surgery, factors related to the patient (e.g., advanced age, obesity, American Society of Anesthesiologists (ASA) physical classification ≥ 2, and COPD) and the surgical procedure (e.g., emergency surgery, prolonged surgery, and general anesthesia) were found to be predictors for the development of PPC (44). In an observational study in 29 countries, Neto et al. identified 13 independent risk factors for PPC, including higher age and ASA-physical classification, preoperative anaemia, a preoperative low peripheral oxygenation ($SpO_2$), a history of active cancer or obstructive sleep apnea, surgery exceeding 1 hour, and emergency surgery, to mention a few (49). A multicenter study by a perioperative research network including 1,202 patients undergoing non-cardiothoracic surgery found that nearly 1 in 3 patients with severe illness (classified as ASA-physical classification ≥3) and with a surgery exceeding 2 hours suffered from PPC, with a high prevalence of atelectasis (55). The group concluded that atelectasis and pleural effusion, mainly considered to be mild PPC, requires increased attention and preventive treatment because it seems to be associated with decreased oxygenation, increased hospitalization, and increased risk of mortality (55).

Type, technique, and location of surgery and duration of anesthesia have been brought up as perioperative risk factors for PPC in abdominal surgery, and especially anesthesia exceeding 2 hours, surgery close to the diaphragm, upper abdominal surgery, and open surgery have been associated with an increased risk for PPC (55-57). Preoperative factors, as previously mentioned, might also contribute to the increased risk for PPC, for example, advanced age, obesity, smoking history, lung disease, and comorbidities (44, 57, 58). Factors related to the surgery, the anesthesia, and the patients may have an impact on the risk of PPC on their own, but the risk is likely increased if the factors are combined (44, 55). Postoperative interventions such as breathing exercises and mobilization have been considered to be important to counteract respiratory complications after surgery and anesthesia.

## 2.5 Mobilization after abdominal surgery

In 1899, the first known report about interventions to facilitate recovery after laparotomy was published (59). Patients were recommended to turn in bed immediately after uterus and appendix surgery and were permitted to be out of bed within 24 hours instead of being bedbound for days, and moreover they were allowed to eat at an earlier phase. This led to patients starting to move more naturally, which entailed hunger, normal bowel movements, better physical and mental condition without any side effects, and most importantly a shorter length of hospital stay compared with those treated according to usual practice (59). The results sparked great interest regarding the post-operative treatment of abdominal surgery and led to several studies in the subject (60, 61). However, it was not until after the Second World

War and a meeting concerning the “evil of bedrest” in the middle of the 1900s that mobilization early after surgery began to have a clinical impact around the world (4). In a case control report from 1944, nearly a 50% reduction in postoperative complications (including atelectasis and pneumonia) was observed in 500 cases who had the head of their bed elevated at the day of surgery and were mobilized out of bed and walking a few steps the morning after surgery compared to similar cases treated according to standard of care, i.e., staying in bed for 10–14 days after surgery (62).

Over the years, however, the combination of gradually more sophisticated anesthesia and refinement of surgical techniques meant that increasingly advanced surgery became possible even in patients with comorbidities and increased age. At the same time, the frequency of complications increased and so did the patients' stay in hospital (60). As a way of overcoming these negative consequences, a concept called fast-track surgery was developed in 1994 and was initially tested on patients who underwent coronary bypass surgery (63). The concept involved eight principles, from preoperative education of the patient, to early extubation, accelerated mobilization and rehabilitation the morning after surgery, and early discharge to mention a few, and resulted in a significant decrease in the duration of intensive care (63). When the concept was applied in patients undergoing colonic surgery, it included a multimodal rehabilitation program in which patients were mobilized on the afternoon or evening of the day of surgery, resulting in improvements in postoperative recovery (64, 65). However, in 2001 a group of surgeons developed the Enhanced Recovery After Surgery protocol (ERAS) (10). The ERAS concept involves a multimodal action plan where a combination of interventions pre-, peri-, and postoperatively (for example, structured treatment of pain, pre- and postoperative nutritional support, and what is called “early mobilization”) is applied to facilitate the quality of the recovery for patients going through surgery (10). The main reason for this approach has been to find multimodal evidence-based ways to improve and refine perioperative care, reduce surgical stress, reduce postoperative complications, improve physical recovery, and shorten the hospital stay (10, 66). Today, the concept is applied in many types of surgery, including colorectal, gynecologic/oncologic, radical cystectomy, and pancreatic surgery (8, 9, 67, 68). The concept has been proven to minimize the risk of postoperative complications after surgery and to shorten the length of stay at hospital, even though the studies have mostly been rather small with quasi-experimental designs (69).

### 2.5.1 Different definitions of early mobilization

In recent years, the term early mobilization has begun to be widely imbedded in protocols such as in the ERAS concept, but also during intensive care (70-72). The term early mobilization is rather vague in definition of type, commencement, duration, and frequency (8-10, 12, 67, 72-74):

- Early Mobilization at intensive care units – Patients should be mobilized within 24 to 72 hours (72).
- Early Mobilization for ERAS colorectal surgery - Patients should be mobilized on the day of surgery (8, 10).
- Early Mobilization for ERAS gynecologic and oncologic surgery – Patients should be encouraged to mobilize within 24 hours (12).
- Early Mobilization for ERAS pancreatic surgery - Early and active mobilization should be encouraged from day 0 (75).
- Early Mobilization for ERAS radical cystectomy – Early mobilization (9).

In the ERAS concept, early mobilization is given a high recommendation, though with a low evidence grade (10). Notably, studies within the ERAS concept are based on the total effect of the concept, not the isolated effect of the mobilization intervention (5, 76, 77). Moreover, compliance to recommendations might be low (76), and a previous observational study found that only 50% of patients were mobilized according to ERAS recommendations for colorectal surgery at the day after surgery (POD 1) (78).

In light of what has been mentioned above, mobilization in this thesis is defined as **immediate mobilization,** meaning being out of bed to sit in a chair within 2 hours after arrival at the postoperative recovery unit after elective abdominal surgery.

## 2.6 Physiotherapy interventions to improve respiratory function after surgery

Physiotherapists have been involved in the care of patients who have undergone surgery since the beginning of the 1900s (79). Initially, the treatment consisted of mostly passive manual techniques such as clapping and vibrations on the chest wall combined with positioning of patients in bed to loosen secretions and improve respiration (79). Current physiotherapy after abdominal surgery involves the patient in a more active way and seeks to prevent postoperative complications and to preserve and improve the patient's physical status with the overarching aim of an enhanced recovery. All of this is done in collaboration with the other caregivers around the patient. To prevent PPC after abdominal surgery, different methods are used, alone or in combination, based on the individual patient's needs (80, 81). Interventions with the aim to normalize FRC and alveolar ventilation seem to be crucial in this regard, and the first method of choice for most clinicians is usually mobilization followed by different breathing techniques (81).

### 2.6.1 Breathing exercises and their impact on respiratory function

Breathing exercises are an important component in post-operative care. To sigh deeply or to actively perform a deep inspiration are two efficient and easy ways to increase the inspiratory volume. Combining an active deep inspiration with holding the breath at peak inspiration results in an increased volume and compliance, and it may also increase surfactant levels in the alveoli (36, 80, 82).

In the Swedish context, the addition of breathing exercises with a positive expiratory pressure (PEP) is common after abdominal and thoracic surgery (83-85). PEP breathing, depending on the technique, can be used to increase the tidal volume and subsequently to normalize the FRC in the lungs after surgery (84). If the aim is to increase FRC, the patient is instructed to take a deep breath, slightly larger than normal, followed by a somewhat active expiration into the PEP device to reach and sustain a mid-expiratory pressure of 10–20 $cmH_2O$ before a new inspiration starts (84, 86). At least 5–6 consecutive breaths are required (86). A previous study in patients undergoing cardiac surgery found that 3 sets of 10 breaths are superior to 1 set of 10 breaths (87).

The evidence for the use of PEP respiration after abdominal surgery is limited and is based on a small number of studies on rather small study samples and with inconsistent designs and treatments, and the duration, frequency, and treatment pressure of the intervention varies in the studies (84). Moreover, many of those studies were published in the 1980s and 1990s and anesthesia, surgical techniques, and postoperative treatments have changed since then (88).

The following studies are interesting in terms of the impact on respiratory function. When PEP breathing with blow-bottles was used with eight postoperative patients, FRC increased significantly, while arterial oxygenation ($PaO_2$) was unaffected. The increase in FRC was suggested to be due to the combination of PEP breathing and the initial large and sustained deep breaths (89). In a small randomized controlled trial involving 43 patients undergoing upper abdominal surgery, Ricksten et al. (90) found that patients allocated to PEP breathing administered with a face mask at a pressure of 10–15 $cmH_2O$, with 30 breaths every waking hour twice daily from the day of surgery, had similar results in $PaO_2$ and FVC as those allocated to continuous positive airway pressure (CPAP) at the same pressure, duration, and frequency. Both groups had increased $PaO_2$ on the day after surgery. Furthermore, both treatments appeared to reduce the incidence of postoperative atelectasis compared to an incentive spirometer (90). On the contrary, another randomized controlled trial (RCT) involved 51 patients who underwent upper abdominal surgery and who were classified as high risk of PPC and who were exposed to PEP, IR-PEP (Inspiratory Resistance-PEP), or conventional physiotherapy starting at the day of surgery. All groups had a high rate of PPC, there were no differences in the respiratory outcomes of $PaO_2$, $SaO_2$, or FVC, and none of the groups were close to their preoperative values for $PaO_2$ and $SaO_2$ (91). It should be noted that neither the study by Ricksten (90) or the study by Christensen (91) used an untreated control group. The RCT by Fagevik Olsén (92) included an untreated control group and found that the group (including patients with both high and low risk of PPC) who were randomized to IR-PEP breathing with 30 deep breaths during the day after extensive abdominal surgery had fewer PPC compared to the untreated group. However, the treatment group also received one session of preoperative cardiorespiratory physiotherapy with recommendations to change position in bed and to mobilize as early as possible postoperatively and to cough and huff between every tenth breathing exercise, and these might be considered as possible confounders. Yet another study by Westerdahl et al. (93) found that patients who performed PEP breathing exercises at a pressure of 10 $cmH_2O$ had a reduced atelectatic area and had increased FVC and $FEV_1$ postoperatively (day 4 after thoracic surgery) compared to the controls who performed no breathing exercises. However, no differences in $PaO_2$, $PaCO_2$, or length of stay at the intensive care unit and hospital were observed between the groups.

Previous studies have suggested that the frequency of the chosen breathing technique and individual guidance and supervision while performing the technique are more important in performing breathing exercises, such as PEP breathing, than the actual therapy (84, 86-88, 94).

PEP breathing exercises might be beneficial when it comes to improvements in FRC, reductions in the atelectatic area, and improvements in respiratory outcome (87, 90, 92, 93). To prescribe breathing exercises with PEP routinely to patients who have undergone abdominal surgery, as a way to counteract PPC, might be questioned because there still is no solid evidence for its effectiveness (88).

### 2.6.2 The impact of mobilization on respiratory function

Position has an impact on FRC, and mobilization (to sit or stand) is known to improve FRC and alveolar ventilation in healthy spontaneously breathing persons (23, 30, 95), as well as in patients after surgery (96-98). The influence of different body positions on FRC (liters), in an awake, spontaneously breathing adult of 1.70 m height is shown in figure 2.

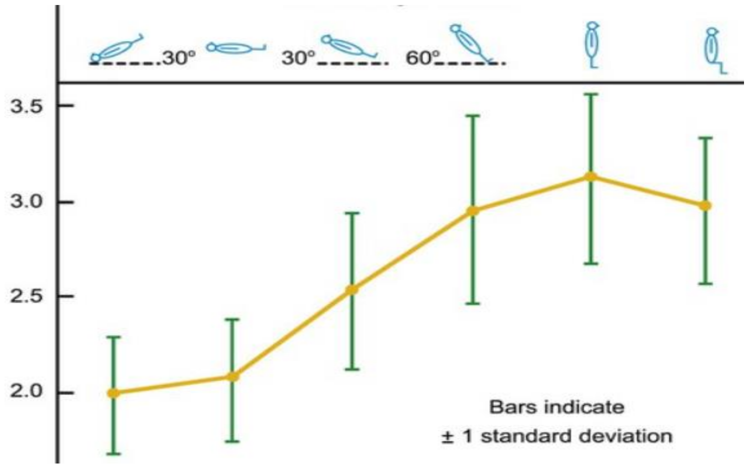


**Figure 2**, showing the influence of different body positions on FRC, from Lumb (20), with permission from Elsevier.

An explanation for the impact on FRC when mobilizing the patients to a sitting or standing position compared to supine bedrest might be the gravitational effect. When standing or sitting, the diaphragm can move and expand freely without any negative impact or pressure from the abdominal contents, thus allowing a normal contraction. This entails increased lung volume, with the even distribution of air inflating collapsed airways and improving alveolar ventilation (27, 30, 99).

The studies by Meyers et al. (100) and Hsu et al (98) with FRC as the primary outcome found a decrease in FRC after surgery compared to preoperative values. The decrease was the greatest from day 0 to 3 after surgery; however, when the patients were mobilized to sitting out of bed the FRC increased compared to while sitting or lying supine in bed (98, 100). The studies were similar in design, settings, materials, and method, but neither were randomized and both consisted of small sample sizes.

Mobilization seems to improve $PaO_2$ and $SpO_2$ compared to being cared for in bed, and it seems that $PaO_2$ and $SpO_2$ return to close to normal values earlier with mobilization (101, 102). In a study by Scheidegger et al. (101), two groups were compared in terms of $PaO_2$, $PaCO_2$, and pH preoperatively and at 4 and 24 hours postoperatively. The intervention group underwent mobilization, i.e. walking and sitting up in a chair, while the controls were given bedrest. After 4 hours both groups showed a significant decrease in $PaO_2$, while after 24 hours only the intervention group showed an increase in $PaO_2$, with the $PaO_2$ close to preoperative values. No statistical differences in $PaCO_2$ or pH after 4 or 24 hours were observed between the groups (101). In the study by Mynster et al. (102), a group of 12 patients were mobilized from supine, to sitting in bed with the head of the bed raised to 70°, to standing after surgery. Preoperative measurements of peripheral oxygenation $SpO_2$ were compared to the values at day 1, 4, and 7 after surgery. $SpO_2$ decreased significantly in all patients the first day after surgery compared to preoperative values. However, all patients had a significant increase in $SpO_2$ when they were mobilized compared to being supine or sitting in bed. At day 7 after surgery $SpO_2$ returned to preoperative values in all patients (102).

Walking within 4 hours after lobectomy also seems to be feasible and safe and to reduce the need for additional oxygen 2 days after surgery (103). Patients assigned to mobilization within 4 hours after pancreatic surgery had a higher $SaO_2/FiO_2$ at the day of surgery compared to the untreated control group, even though the average sitting time was only 6 minutes (104). Moreover, the intervention group required less additional oxygen the day after surgery.

Several studies have reported the effects of diverse mobilization interventions (7, 48, 71, 96, 105-110), but only a few have investigated the effect of mobilization or position on the respiratory system, such as $SpO_2$ and $PaO_2$ (101, 102), FVC (98, 100), maximal inspiratory pressure (MIP)/maximal expiratory pressure (MEP) (111), or PPC (112, 113). However, the types of mobilization interventions and the durations and the frequencies of the interventions and the outcomes have varied. All of this makes it difficult to interpret the results and to compare the different studies. Also, some studies were randomized but without an untreated control group.

It seems that mobilization after surgery might have a positive effect on FRC as well as on $PaO_2$ and $SpO_2$. The effect of mobilization immediately after abdominal surgery and its impact on respiratory function, however, remains unclear.

## 2.7 Patients´ and healthcare professionals` experiences of mobilization

Healthcare professionals are aware of and educated in the positive effects of physical activity and mobilization early after surgery (114, 115). However, early mobilization after surgery might still be associated with perceived barriers due to lack of time, resources, adequate staffing, or mobilization aids or a leadership or culture that does not prioritize mobilization (114-117), and these barriers are similar to when mobilizing critically ill patients (70, 118-124). However, the following factors were identified by healthcare professionals as important for the facilitation of early mobilization in critically ill patients: to have a champion/team leader for the mobilization process and available team members (nurses and physiotherapists) who are ready to assist (125, 126), to use predefined mobilization protocols to more easily identify when and for how long patients should be mobilized (71, 119, 121, 127), and to have knowledge about the negative and positive physical and mental aspects of patients being or not being mobilized (124, 125, 127). Patients seem to appreciate mobilization and associate it with pleasant emotions because it helps them regain their independence and is seen as a factor that can facilitate recovery and discharge from the hospital (128-131). At the same time, patients in intensive care and postoperative care have expressed similar concerns that weakness, pain, and fatigue are obstacles to early mobilization (117, 128, 130-134). Freedom from pain and nausea and independence in mobilization were rated as the most important factors in the ERAS concept by patients in Norway, Scotland, and the Netherlands undergoing major hepatic, colorectal, or esophagogastric surgery (135).

Interaction, information, and collaboration with the healthcare professionals has been shown to be crucial to patients for carrying out mobilization (117, 132, 133, 136). In addition, teamwork among the caregivers has also been stressed as important by both healthcare professionals and patients (117, 137, 138). Therefore, it is of utmost importance that the staff be motivated and take the time to help the patient to mobilize (117). This is especially because patients experience that positive attitudes among healthcare professionals affects them in a positive way, making it easier to struggle through exhausting activities such as mobilization (117, 132).

## 2.8 THEORETICAL FRAMEWORK

The Movement Continuum Theory of physical therapy (139) provides the overall theoretical framework for this thesis. The key concept of the theory is movement, and it is based on physiotherapists' ways of perceiving and using the concept of movement in a patient-centered perspective. The theory contributes to reflection and stances on various aspects of movement with three general philosophies – *"1) movement is essential to human life, 2) movement occurs on a continuum from the micro level (the cells) to the macro level (the human in society), and 3) the movements on the continuum are influenced by physical, psychological, social, and environmental factors"* (139).

Movement Continuum Theory means that each person has a maximum, a current, and a preferred level of movement capability (139). In case of sickness, trauma, or surgery, physical function and capacity in humans deteriorates. In patients who have undergone abdominal surgery, the respiratory function and the ability to move may be affected immediately after the surgery. This affects the patient not only in the immediate postoperative period but can also mean that activities of daily living are affected for days up to weeks after the surgery. The patient's preferred capability is then not in line with their current physical capability, and thus there is a gap between actual and preferred capability (139). Physiotherapy aims to improve the patient's physical ability with the help of various interventions adapted to the patient's problems and needs. The physiotherapist needs to titrate the respective continuum to determine at what level the patient needs support to improve their capability to move along the continuum in order to get closer to their preferred level. By applying mobilization immediately after surgery, already in the postoperative recovery unit, the gap between current function and preferred capability might be reduced more quickly.

# 3 RATIONALE

In recent years, the focus in abdominal surgery has been on refinements of surgical techniques (14-16), multimodal pre-optimization (140, 141), multimodal action plans for enhancing patient recovery (10), and early mobilization protocols (71, 105) as ways to prepare and optimize the patient prior to surgery and to minimize complications after surgery. However, quite little focus has been placed on optimizing the patient's respiratory status in the immediate postoperative stage.

Mobilization as early as possible after abdominal surgery is highly recommended to enhance recovery and is considered crucial to prevent postoperative complications. Still, the evidence grade for the isolated effect of the intervention is low. Moreover, there seems to be a knowledge gap regarding the respiratory effect of mobilization alone immediately after abdominal surgery. Consequently, there is also a knowledge gap regarding when mobilization should commence after surgery and what its optimal duration should be with regards to immediate effects on respiratory function such as $SpO_2$ and $PaO_2$. Therefore, there is a need to investigate whether mobilization immediately (within hours after surgery) already at the postoperative recovery unit is worthwhile for the patient in regards to respiratory improvements. Moreover, if we are to continue to recommend mobilization as early as possible after surgery, we need to investigate how patients experience being mobilized because they are the primary participants. For the same reason, in order to refine the postoperative care of patients there is also a need to understand and explore healthcare professionals´ experiences of working with mobilization. These perspectives have previously been overlooked.

In view of this, the information collected from explorative quantitative and qualitative research will extend the knowledge of researchers, healthcare professionals, and patients and will help fill the knowledge gap regarding the respiratory effect of mobilization after abdominal surgery and will improve patient outcome. A patient who is mobilized at an early stage will probably become a more active participant in their own care.

# 4 AIMS OF THE THESIS

## Overall aim

This thesis aimed to evaluate the respiratory effects of immediate mobilization during the postoperative period among patients undergoing elective, open, or robot-assisted laparoscopic gynecological, urological, or endocrinological abdominal surgery and to describe patient and healthcare professionals´ experiences of such an early mobilization procedure.

## Specific aims of the papers

**I** To investigate the respiratory effect of immediate mobilization of patients within 2 hours after arrival at the postoperative recovery unit after elective open or robot-assisted laparoscopic gynecological, urological, or endocrinological abdominal surgery.

**II** To investigate the relationship between time to mobilization and duration of mobilization and the outcome in oxygenation in terms of mean $SpO_2$ (%), $PaO_2$ (kPa), and length of stay at the postoperative recovery unit.

**III** To explore and describe patient experiences of mobilization immediately after surgery.

**IV** To describe healthcare professionals´ experiences of being engaged in helping patients mobilize early after abdominal surgery.

# 5 MATERIALS AND METHODS

## 5.1 Study designs

This thesis comprises three clinical studies that resulted in four research papers. **Paper I** was a single-center RCT with three arms. **Paper II** was a secondary analysis encompassing parts of the data from the RCT. In **Papers III** and **IV**, interview studies with a qualitative approach were used. All studies were performed at a university hospital in Stockholm County, Sweden. For more detailed information about the studies, an overview of the papers is presented in table 1.

**Table 1.** An overview of the papers in this thesis.

| **Papers** | **I** (n = 214) | **II** (n = 137) | **III** (n = 23) | **IV** (n = 17) |
|---|---|---|---|---|
| **Trial period** | January to September 2017 | January to September 2017 | March to June 2017 | November 2017 |
| **Participants** | Adults with a planned elective gynecological, urological, or endocrinological open or robot-assisted laparoscopic abdominal surgery with an anesthetic duration of ≥2 hours. Independent in mobilization prior to surgery. | The cohort of patients in the RCT (paper I) who were randomized to and fulfilled the mobilization interventions mobilization only and mobilization and breathing exercises. | Participants in the RCT (paper I) who were randomized to and fulfilled the mobilization interventions mobilization only and mobilization and breathing exercises. | Healthcare professionals involved in mobilizing patients in the RCT (paper I) |
| **Data collection** | Preoperative: $SpO_2$ , Spirometry<br><br>Postoperative at 0–6 hour: $SpO_2$, $PaO_2$, $PaCO_2$, Respiratory insufficiency<br><br>POD1: Spirometry<br><br>2 weeks after surgery: Pneumonia, LoSP and LoSH | A secondary analysis of data from the RCT.<br><br>Preoperative: $SpO_2$<br><br>Postoperative at 0–6 hour: $SpO_2$, $PaO_2$<br><br>2 weeks after surgery: LoSP | Face-to-face interviews (semi-structured guide). | Face-to-face interviews (semi-structured guide). |
| **Data collection period** | 0–6 hours after surgery<br><br>2 weeks after surgery | 0–6 hours after surgery<br><br>2 weeks after surgery | 1–4 days after surgery | 2 weeks |
| **Outcomes** | Primary: $SpO_2$ and $PaO_2$<br><br>Secondary: $PaCO_2$, incidence of pneumonia and respiratory insufficiency, LoSP and LoSH | Primary: $SpO_2$ and $PaO_2$ in relation to initiation of mobilization and duration of mobilization<br><br>Secondary: LoSP | From transcripts to overarching theme. | From transcripts to overarching theme. |

Abbreviations: RCT = Randomized Controlled Trial, LoSH = Length of Stay at Hospital, LoSP = Length of Stay at Postoperative recovery unit.

## 5.2 Participants and context

All phases in the studies, including screening, recruitment of participants, and assessment of data, were conducted in clinical settings at an outpatient clinic and/or at the postoperative recovery unit at Karolinska University Hospital Solna in Stockholm. The hospital is a tertiary care hospital divided into two sites, Solna and Huddinge. In Solna approximately 10,000 elective surgeries per year are performed in adult patients (thoracic surgery excluded).

### 5.2.1 Recruitment and eligibility criteria

**Paper I**

Screening and recruitment of participants in the RCT was conducted at the presurgical outpatient clinic at Karolinska University in Solna, where patients had a pre-planned appointment approximately 2 weeks prior to surgery. Adults (≥18 years old) scheduled for open or robot-assisted laparoscopic gynecological, urological, or endocrinological surgery in the abdomen, with a planned anesthetic duration exceeding 2 hours, Swedish or English speaking, and independent in mobilization prior to surgery were considered eligible for inclusion. Screening was performed by a research nurse who approached eligible patients, provided them with written and verbal information about the trial, and asked about participation. Written informed consent was obtained from all included patients.

Two exclusion procedures were established. Prior to surgery, patients were excluded if they required assistance for mobilization, were unable to understand instructions, or if they were enrolled in contemporary studies at the postoperative recovery unit. After surgery, prior to randomization, patients were excluded if the surgical procedure prevented mobilization out of bed or if the patient was considered unfit for mobilization due to cardiorespiratory instability requiring immediate treatment or if the patient arrived at the recovery unit after 6 p.m. Inclusion of patients commenced on January 23, 2017, and was finalized on September 22, 2017.

**Paper II**

This was a secondary analysis of parts of the data collected in the previous RCT (paper I), and the participant data were thus collected from the RCT dataset. This paper included patients who were assigned to and completed any of the mobilization interventions in the RCT, including mobilization only and mobilization and breathing exercises. Accordingly, data for patients in the RCT who were assigned to but did not receive any of the mobilization interventions and data for patients assigned to be controls (bedrest) were excluded from the analysis.

**Paper III**

Patients were recruited from the cohort of patients in the RCT (paper I) who were randomized to either intervention, mobilization and breathing exercises or to mobilization only, because the aim was to explore patient experiences of mobilization. To achieve as broad a range of experiences as possible, a purposeful sampling was applied (142). Thus, patients were included based on a maximum variation of age, sex, surgery, ASA physical status classification (143), anesthetic duration, and total time of mobilization. All eligible patients in the RCT received written and verbal information about the interview study already at inclusion in the RCT. The day after surgery, potential participants were approached by the interviewer of the study (not previously known by the participants) and again asked about participation in the study. Participants had to understand and speak Swedish to be able to participate. Inclusion commenced on March 1, 2017, and ended on June 30, 2017.

**Paper IV**

Eligible participants considered for inclusion in this qualitative interview study were healthcare professionals at the postoperative recovery unit who took part in the immediate mobilization of patients during the study period of the RCT (paper I), and this included nurses, assistant nurses, physiotherapists, and anesthesiologists. An email was sent out by the head nurse at the postoperative recovery unit containing information about the study with an invitation to participate. Screening and recruitment were then performed by the same head nurse. A purposeful sampling was applied with the aim of obtaining heterogeneity of age, sex, working experience, and professions (142). No exclusion criteria were applied. Inclusion commenced in October 2017 and ended on November 14, 2017.

## 5.3 Data collection

Data collection for this thesis commenced in January 2017 and was finalized in November 2017. All collected data were anonymized.

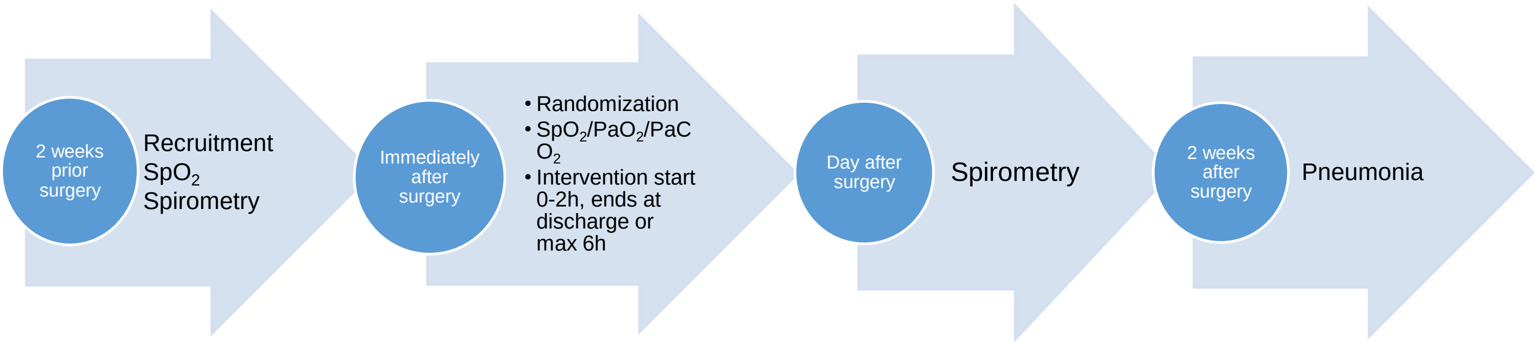


**Figure 3**, showing the procedure for data collection in paper I, the RCT.

### 5.3.1 Procedures

**Paper I**

Prior to start of the RCT (paper I), a study protocol was established and registered at ClinicalTrials.gov (NCT02929446).

*Prior to surgery*

At inclusion, baseline data including $SpO_2$ and spirometry (FVC, PEF, $FEV_1$, $FEV_1$/FVC) (144), weight, and length, were assessed by a research nurse while patients were at their pre-planned appointment with the anesthesiologist approximately within 2 weeks prior to the surgery.

*After surgery (POD 0)*

At arrival to the postoperative recovery unit, immediately after surgery, a research nurse, independent of the trial, randomly assigned the patients to one of the following three groups:

1) Mobilization out of bed to sit in a chair.
2) Mobilization out of bed to sit in a chair and standardized breathing exercises.
3) Control – no mobilization and no breathing exercises during the study trial.

A computer-generated randomization in blocks of nine was used to allocate patients to the different groups (1:1:1). Allocation was concealed by random selection of opaque closed envelopes prepared by an investigator with no further involvement in the trial.

$SpO_2$, $PaO_2$, and $PaCO_2$ (arterial blood gas sample) were assessed immediately upon arrival at the postoperative recovery unit and thereafter every hour for a maximum of 6 hours or sooner if discharged to the surgical department. Occurrence of respiratory insufficiency ($SpO_2$ <90%, or $PaO_2$ <8 kPa and/or $PaCO_2$ ≥6.5kPa) (51) was registered if present (at the hourly blood sample test).

*Demographic, surgical, and treatment-related data* were retrieved from the medical records and from the bedside case report file (CRF) at the postoperative recovery unit.

*The day after surgery (POD 1)*

A new spirometry was performed in the morning by a physiotherapist blinded to group allocation.

*Two weeks after surgery*

Data regarding occurrence of pneumonia (51) and length of stay at the recovery unit and the hospital were retrieved from the medical records.

**Paper II**

This study was a secondary analysis of parts of the data from the RCT (paper I). Demographic and treatment-related data were assessed from the RCT dataset.

*Treatment-related data* included $SpO_2$, $PaO_2$, mobilization initiation time, duration of mobilization, and length of stay at the postoperative recovery unit.

**Paper III**

Prior to the study start, a semi-structured interview guide was developed with pre-defined topics, open-ended questions, and probing questions about patient experiences of immediate mobilization at the recovery unit. The guide was tested by the author of this thesis in a pilot interview, and this led to focusing more on open-ended and probing questions in order to facilitate the patient in describing their experiences (142, 145).

*Individual face-to-face interviews* were conducted in a secluded room at the patient's ward within 1–4 days after surgery with the intent of capturing the patients' experiences of immediate mobilization while still fresh in their minds. The interviews were conducted by a physiotherapist who was not involved in the RCT (study I) and was not previously known to the patients. Two of the interviews were conducted by the author of this thesis. All interviews were audio recorded and then transcribed verbatim by a professional transcriber.

*Descriptive data* such as age, sex, ASA physical status (143), type of surgery performed, duration of anesthesia, and mobilization were collected from the medical records, the CRF, and the RCT database (study I).

**Paper IV**

A semi-structured interview guide with pre-defined topics, open-ended questions, and probing questions about the experience of participating in mobilization was developed prior to the study start. The guide was not tested, but the first interviews indicated that the wording was clear and that it rendered rich answers to the research questions (142).

Within a month after end of the RCT, during a period of 2 weeks in November 2017, *individual face-to-face interviews* took place. The time for the start of the study and for commencing the interviews was chosen in close connection with the completed RCT so that the healthcare professionals would have experiences of immediate mobilization still fresh in their minds. All interviews took place in a secluded room in close proximity to the postoperative recovery unit. The location was chosen to enable the healthcare professionals' participation in the study. The interviews were conducted by two physiotherapists not previously known to the healthcare professionals. All interviews were audio-recorded and then transcribed by a professional transcriber.

*Descriptive data* were collected at inclusion prior to the interviews and included age, sex, profession, year in the profession, and number of years working at the postoperative recovery unit.

### 5.3.2 Measurements

*$SpO_2$ (%)* was selected as a primary outcome to evaluate the effect of the interventions in the RCT on patients' respiratory function (Paper I) and to investigate the effect of mobilization initiation time and total mobilization time in relation to respiratory function (Paper II).

The preoperative baseline measurement at inclusion was standardized with patients sitting in a chair and resting for 10 minutes prior to the measurement (146, 147). The same type of oximeter (TuffSat Pulse Oximeter; GE Datex-Ohmeda, Inc, Frankfort, KY, USA) was used for all patients. $SpO_2$ was assessed upon arrival at the postoperative recovery unit and then performed every hour thereafter, for a maximum of 6 hours or sooner if discharged to the surgical ward. The first assessment at arrival to the postoperative recovery unit was performed with the patient in a supine position in bed. Thereafter, only the controls were assessed in a supine position, and the interventions – mobilization only and mobilization and breathing exercises – were assessed sitting in a chair or in bed (minimum 45° sitting). For patients where oxygen was administered, it was disconnected 15 minutes prior to each and every assessment (from arrival to discharge) in order to be able to compare patients over time within and between groups. According to clinical standards, $SpO_2$ was continuously monitored with a pulse oximeter from arrival to discharge at postoperative recovery units because it shows a continuous trend for respiratory status in the patient (147).

Blood gas analysis allows a direct measure of arterial oxygenation $PaO_2$, (kPa) and arterial carbon dioxide $PaCO_2$, (kPa) (148). *$PaO_2$* was selected as a primary outcome to evaluate the effect of the interventions in the RCT on patients' respiratory function (Paper I) and to investigate the effect of mobilization initiation time and duration of mobilization in relation to respiratory function (Paper II). *$PaCO_2$* was considered a secondary outcome to evaluate the effect of the interventions in the RCT on patients' respiratory function (Paper I).

$PaO_2$ and $PaCO_2$ were assessed via the patients´ arterial line (arterial radialis) as a blood gas sample (148). Upon arrival at the postoperative recovery unit after surgery the first assessments of $PaO_2$ and $PaCO_2$ were performed, then subsequently every hour, in the same standardized way as previously described for $SpO_2$ in regards to patient position and disconnection of oxygen.

*Respiratory insufficiency* (Paper I) is considered a postoperative pulmonary complication and was defined as $SpO_2$ <90% or $PaO_2$ <8kPa and/or $PaCO_2$ ≥6.5 kPa according to European Perioperative Clinical Outcome (EPCO) definitions (51). Complications were registered if present at any of the hourly assessments of $SpO_2$, $PaO_2$, and $PaCO_2$ during the data collection in the RCT.

*Spirometry (Paper I).* A portable microspirometer (Carefusion MicroLoop; Vyaire Medical Inc; Chatham Maritime, Kent, UK) was used to measure lung function as FVC, $FEV_1$, $FEV_1$/FVC, and PEF (149). To compare pre- and postoperative lung function between the intervention groups and the controls, measurements were performed at recruitment, prior to surgery, and then again, the day after surgery. The spirometry was performed according to standardized recommendations in a sitting position using a nose clip (149). Weight and length were measured at recruitment prior to spirometry. The same two persons (a research nurse and a physiotherapist) not involved in the interventional parts of the RCT measured the patients. The same spirometer was used for all assessments. At the day after surgery and prior to spirometry, patients rated their pain on a numeric rating scale, where 0 = no pain and 10 = worst imaginable pain (150). If pain was rated ≥3, analgesics were given and a new attempt at spirometry was made later.

*Pneumonia* is considered a postoperative pulmonary complication (51), and the intervention groups and the controls were compared with regards to occurrence (Paper I). Pneumonia was considered present if the patient had newly evolving chest radiograph infiltrate and two or more of the following criteria: temperature of >38.3°C, leukocyte count of >12,000 $\mu l^{-1}$, and/or purulent sputum according to EPCO definitions (51). Registration of pneumonia was made by a medical doctor at the surgical ward who was blinded to the randomized controlled trial. Data were retrieved from the patient's medical record 2 weeks postoperatively.

Data regarding *Length of stay at postoperative recovery unit* was considered as a secondary outcome in Paper I and Paper II. *Length of stay at hospital* was used as a secondary outcome measure in Paper II. Data for total stay at the postoperative recovery unit and at hospital were retrieved from the medical records 2 weeks post-surgery because all patients were considered to be discharged at that time point.

*Pain and nausea* might be considered an obstacle for mobilization (3). Thus, at every hour from arrival to discharge all patients in the RCT (Paper I) rated pain and nausea on a numeric rating scale where 0 represents no pain/nausea and 10 represents the worst pain/nausea imaginable (150).

Data on *initiation of mobilization and duration of mobilization* (Paper I and II) were registered in a CRF for all patients randomized to any of the mobilization interventions in the RCT (Paper I). For patients who were not able to fulfil mobilization intervention, the reason for this was registered in the CRF.

### 5.3.3 Interventions

**Paper I**

Interventions were to start within 2 hours after arrival at the recovery unit and were to be continued for a maximum of 6 hours, or earlier if discharged to the surgical department. The three groups the patients were randomly assigned to mobilization only, mobilization and breathing exercises, or to be controls.

*Mobilization*

Patients were instructed to *mobilize out of bed*, assisted by the healthcare professionals at the postoperative recovery unit if needed, to sit in a chair (or unsupported on the bedside if unable to stand and transfer to a chair) for as long as possible. If required, this was interspaced by bedrest for a maximum of 1 hour. While in bed, the patient was in a sitting position with a minimum of 45° elevation.

*Mobilization and breathing exercises*

The *mobilization* intervention was identical to that previously described. The instructions for *breathing exercises* were standardized as follows. Patients were instructed and supervised by a physiotherapist to perform breathing exercises using the PEP technique (84). The patients were instructed to perform a set of 10 consecutive breaths three (with a short 30–60 second pause between each set) at every hour with a PEP device (PEP T-piece and Resistor; Intersurgical AB, Danderyd, Sweden) at a mid-expiratory pressure of 10–15 $cmH_2O$ (84). The pressure was controlled at every breathing exercise by the physiotherapist by use of a manometer. Breathing exercises were always performed with the patient in an upright sitting position in a chair or in bed.

*Controls*

Patients assigned to control group were instructed to stay in bed (a maximum of 30° elevation). No breathing exercises were to be performed.

## 5.4 Analysis

An overview of the variety of the analysis used in Papers I–IV is presented in table X. The statistical analyses in this thesis were performed using Statistical Package for the Social Sciences Version 24 and 27 (SPSS, IBM Corporation, NY, USA).

**Table 2**. Overview of the descriptive and analysis methods used in papers I to IV.

| **Statistics** | **Paper I** | **Paper II** | **Paper III** | **Paper IV** |
|---|---|---|---|---|
| **Descriptive** | | | | |
| Counts | * | * | * | * |
| Percentages | * | * | | |
| Range | | | * | * |
| Mean (SD) | * | * | | |
| Median (IQR) | * | * | * | * |
| **Quantitative analysis** | | | | |
| Pearson's correlation | * | | | |
| Students t-test | * | * | | |
| Chi-squared | * | * | | |
| Fischer's exact test | | * | | |
| Mann–Whitney U-test | | * | | |
| One-way ANOVA | * | * | | |
| Friedman´s ANOVA | * | | | |
| Kruskal Wallis | * | * | | |
| Linear regression | | * | | |
| Logistic regression | * | | | |
| Mixed model analysis | * | * | | |
| **Qualitative analysis** | | | | |
| Content analysis Graneheim & Lundman | | | * | |
| Content analysis Elo & Kyngäs | | | | * |

Abbreviations: SD = Standard Deviation; IQR = Interquartile range

### 5.4.1 Quantitative analysis

The statistical methods used were parametric or non-parametric depending on if the data were normally distributed or not. Normality for continuous data were tested graphically with histograms, boxplots and statistically with kurtosis, skewness, and the Shapiro–Wilks test. Demographic data were thus presented as means and standard deviations (SDs), numbers and proportions, or as medians, ranges, and IQR where appropriate.

**Paper I**

Data for calculating the power analysis were obtained from a previously unpublished pilot study (a master's thesis at KI) and a previous study (87) evaluating breathing exercises in patients who underwent thoracic surgery. We assumed that the treatment would increase $SpO_2$ by 2% (SD = 4) or $PaO_2$ by 0.5 kPa (SD = 1 kPa) compared to the controls. The number of patients required to establish a statistical power of 80% and a significance level of 5% was 63 patients for each group.

Linear mixed model analysis (151, 152) was used for calculation of repeated measurements of $SpO_2$, $PaO_2$, and $PaCO_2$ between the groups as well as over time. Covariates included in the model were assignment group (mobilization only, mobilization and breathing exercises, and control), time for assessment (1, 2, 3, 4 hours), and type of surgery (open or robot assisted). Two-way and 3-way interactions were applied in the model. Age and $SpO_2$/$PaO_2$/$PaCO_2$ at baseline were included as covariates in the models. The linear mixed model analysis (151, 152) was used for spirometry assessments (FVC, $FEV_1$, PEF, and $FEV_1$/FVC) and potential differences between pre- and postoperative data (POD1) and between the groups. Intention-to-treat (ITT) and per-protocol (PP) analyses were conducted according to recommendations for RCT studies (153-155). Bonferroni was used to counteract or reduce the problem of multiple comparisons (156).

Logistic regression was used for analyzing the associations between intervention effects and respiratory insufficiency as well as for associations with pneumonia, with adjustments for potential risk factors. Variables were entered in the models stepwise using forward selection (157). Additional analysis included correlation between the two primary outcomes $SpO_2$ and $PaO_2$ at baseline because not all patients received an arterial needle during surgery.

**Paper II**

For analysis of mobilization initiation time, patient data were categorized as mobilized within the first hour (0 to 1 h) or mobilized between the first and second hour (1–2 h). For analysis of duration of mobilization, patient data were categorized into mobilized out of bed < 30 minutes, mobilized out of bed between 30 to 90 minutes, or mobilized out of bed ≥ 90 minutes. Linear mixed models (151, 152) were used to investigate mobilization initiation time and duration of mobilization in relation to $SpO_2$ and $PaO_2$ (151, 152). The factor of time (1, 2, 3, 4 hours) was applied in each model, and then 2-way and 3-way interactions were conducted. $SpO_2$ and $PaO_2$ at baseline were included as covariates in the models, and adjustments were made for potential risk factors based on reference literature and clinical reasoning on the risk for decreased $SpO_2$/$PaO_2$ after abdominal surgery (157). Linear regression was used to analyze mobilization initiation time and duration of mobilization in relation to length of stay at the postoperative recovery unit (157).

### 5.4.2 Qualitative analysis

**Papers III and IV**

In papers III and IV, content analysis was used for interview transcripts because it is an appropriate method for identifying, organizing, and categorizing the content of a narrative text in a systematic way (158). Inductive manifest analysis of the collected data was considered appropriate with the aim to explore patient and caregiver experiences of mobilization immediately after abdominal surgery. Content analysis as described by Graneheim & Lundman (159) was applied for analysis of the transcribed patient face-to-face interviews in *Paper III*, and content analysis as described by Elo & Kyngäs (160) was applied for analysis of the face-to-face interviews with healthcare professionals in *Paper IV*. The analysis started with a broad reading of the transcribed material in order to get a sense of the entirety. This was followed by reading with the purpose of the study in mind while identifying and marking meaning units in the text related to the purpose, thus representing the preparation phase according to Elo & Kyngäs (160). The next step was to condense the meaning units and then code and sort/group them into categories and subcategories. The categories and the subcategories were abstracted in order to develop an overarching theme in line with the general research topic. According to Graneheim and Lundman, the creation of categories is considered the core of content analysis, and the theme is the thread running through the underlying meaning of the meaning units, codes, and categories (159).

To ensure conformability, before moving on to the next step in the process the research group discussed, validated, and agreed on the analysis (161). The next step was to accompany the subcategories and categories with quotes as a way to enrich the material and to allow transparency and credibility of the analysis (142, 161). While content analysis by according to Graneheim & Lundman (159, 162) takes abstraction of the text into consideration, the method of Elo & Kyngäs stays closer to the text (160). Moreover, the content analysis according to Elo & Kyngäs states the importance of incorporating the phases of 1) preparation, 2) organization, and 3) reporting in order to increase the trustworthiness of the study.

### 5.5 Ethics

The research included in the present thesis was planned and conducted according to Good Clinical Practice (163) and in line with the ethical principles of the Declaration of Helsinki and its later amendments (164, 165). The overall research project was approved by the Regional Ethical Review Board in Stockholm (Dnr: 2015/703-31/1). Three additional applications were made during the research process due to the performance and data collection of the studies (Dnr: 2016/1831-32, Dnr: 2016/2176-32, and Dnr: 2017/836-32). All data obtained from the medical records were handled according to the General Data Protection Regulation (GDPR) and associated regulations and according to ethical considerations at Karolinska University Hospital.

The research group has throughout the entire research project made decisions and reflections according to ethical standards because all of the research in the thesis involves humans. Being a patient treated at a hospital for elective abdominal surgery puts one in a vulnerable situation because one is dependent on and is putting their trust in the hands of the healthcare professionals. As a researcher in an explorative trial, it is important to be aware of the dependent relationship the patient is in. All participants were treated with respect, and their well-being was always more important than the research, thus the importance of the inclusion and exclusion criteria and the ability for the participants to withdraw from the study at any time without providing any explanation. All participants received verbal and written information regarding the purpose of the study prior to inclusion. In summary, all four ethical principles – namely, respect for autonomy, beneficence, nonmaleficence, and justice – were taken into consideration prior to, during, and after the trials (166, 167).

# 6 RESULTS

This section summarizes the main findings of each study in the thesis. Detailed results are presented in each manuscript.

## 6.1 Patient characteristics and recruitment

Patient characteristics in Papers I, II, and III originated from the same cohort of patients in the RCT (paper I), figure 4.

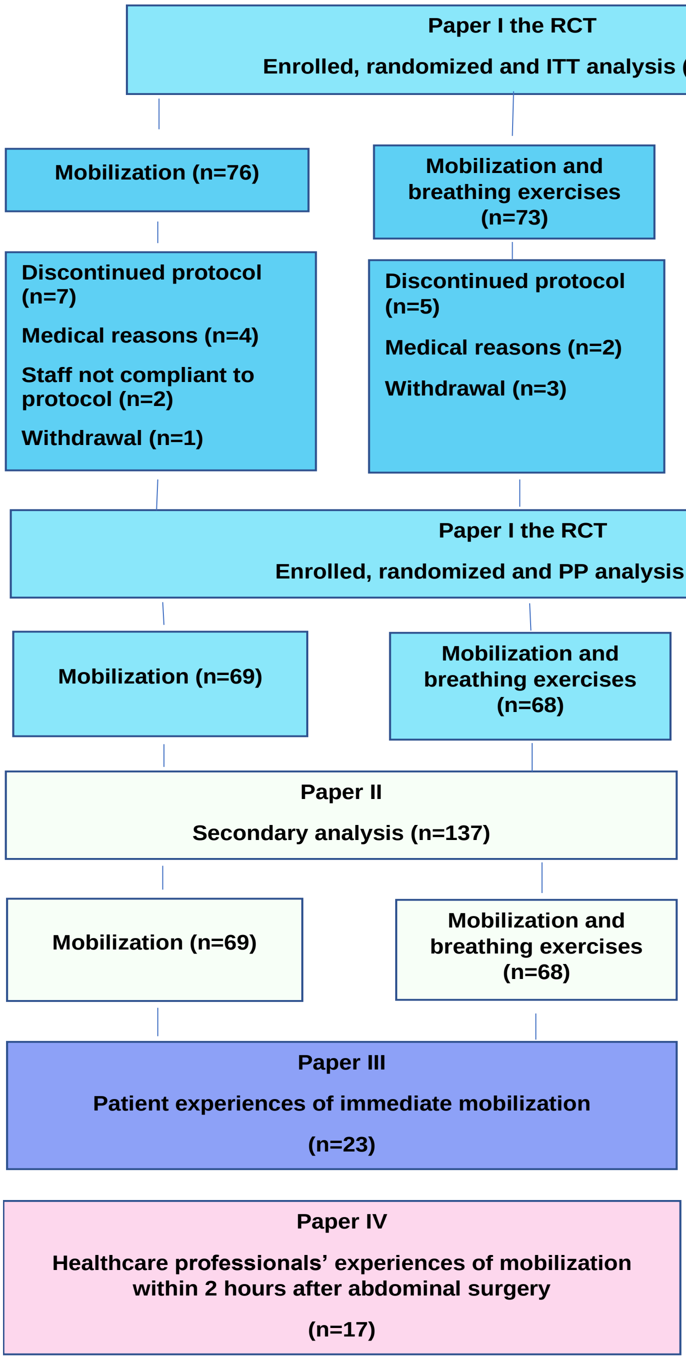


**Figure 4.** Flowchart of the papers I to IV and participants in the present thesis.

**Table 3**. Demographic and perioperative characteristics of the study population in papers I and II.

| **Paper I, ITT population** (n=214) | | | | | **Paper I, PP population** (n=201) | | |
|---|---|---|---|---|---|---|---|
| | | | | | **Paper II** (n=137) | | |
| | **Mobilization only** (n=76) | **Mobilization and breathing exercises** (n=73) | **Control** (n=65) | | **Mobilization only** (n=69) | **Mobilization and breathing exercises** (n=68) | **Control** (n=64) |
| Age, median (IQR) | 69 (60-73) | 72 (64-77) | 68 (59-72) | | 69 (60-73) | 72 (65-77) | 68 (60-72) |
| Women sex, n (%) | 44 (58) | 45 (62) | 41 (63) | | 39 (57) | 42 (62) | 41 (64) |
| Preoperative $SpO_2$ % | 97.2 (1.6) | 97.2 (1.5) | 97.7 (1.4) | | 97.3 (1.6) | 97.1 (1.6) | 97.7 (1.4) |
| ASA physical status, n (%) | | | | | | | |
| *1* | 9 (12) | 1 (1) | 12 (18) | | 8 (12) | 1 (1) | 12 (19) |
| *2* | 46 (59) | 48 (66) | 36 (55) | | 44 (64) | 44 (65) | 36 (56) |
| *≥ 3* | 22 (29) | 25 (33) | 17 (28) | | 17 (24) | 23 (34) | 16 (25) |
| BMI kg/m$^2$, mean (SD) | 28 (5.9) | 27 (6.3) | 26.3 (4.4) | | 28 (5.9) | 27 (6.5) | 26 (4.4) |
| Type of surgery, n (%) | | | | | | | |
| *Gynecological* | 34 (45) | 37 (50) | 30 (46) | | 31 (45) | 34 (50) | 30 (47) |
| *Urological* | 31 (41) | 26 (36) | 26 (40) | | 29 (42) | 24 (35) | 25 (39) |
| *NET, Sarcoma, Adrenalectomy* | 11 (14) | 10 (14) | 9 (14) | | 9 (13) | 10 (15) | 9 (14) |
| Duration of anesthesia, h:min (SD) | 4:3 (1.4) | 4:1 (1.4) | 4:1 (1.3) | | 4:2 (1.6) | 4:1 (1.7) | 4:1 (1.4) |

Abbreviations: ITT = Intention to treat population; PP = Per protocol population; IQR = Interquartile range; BMI = Body Mass Index; NET = Neuroendocrine tumors.

**Paper I**

From January 23 to September 22, 2017, a total of 365 patients were screened for inclusion, and 285 were considered eligible. After exclusion of 71 patients, a total of 214 patients were randomly assigned to mobilization only (n = 76), mobilization and breathing exercises (n = 73), or to be controls (n = 65) and thus included in the ITT analysis (figure 4). After randomization, 13 patients discontinued the protocol because of cardiorespiratory instability (n = 6), healthcare professionals not compliant to the study protocol (n = 2), or withdrawal from the study (n = 5). Thus, a total of 201 patients (mobilization only (n = 69), mobilization and breathing exercises (n = 68), and controls (n = 64)) fulfilled the interventions and were included in the PP analysis (figure 4).

For the entire population, n=214, the ages ranged from 22 to 93 years. There were no statistically significant differences in baseline characteristics between the groups, except for that patients allocated to mobilization and breathing exercises were significantly older, median age 72 (IQR 64 to 77) than the controls, median age 68 (IQR 59-72). Moreover, the mobilization and breathing exercises had a fewer classified as ASA physical status 1, 1 (1%) then mobilization only, 9 (12%) and the controls, 12 (18%) (table 3). Among the 214 patients, nearly 60% were women. Approximately 50% had never smoked. Preoperative $SpO_2$ was 97.2% (1.5) for mobilization only, 97.2% (1.6) for mobilization and breathing exercises and 97.7% (1.4) for the controls. The most common surgery was robot-assisted laparoscopic urological surgery, followed by open gynecologic surgery. The average duration of anesthesia was 4 hours and 30 minutes for mobilization only, and 4 hours 10 minutes for mobilization and breathing exercises and for the controls.

**Paper II**

This paper was a secondary analysis of data from the RCT (paper I). A total of 137 patients who were assigned to and fulfilled the mobilization only (n = 69) and mobilization and breathing exercises (n = 68) interventions were included (figure 4). Demographics were similar between the two groups. Of the 137 included patients, 60% were women, median age 69 (IQR 60 to 73) for mobilization only and 72 (IQR 65 to 77) for mobilization and breathing exercises, table 3. The most common surgery was gynaecological, followed by urological. Nearly 60 % was robot assisted laparoscopic surgery and 40% open surgery. For analyzing the mobilization initiation time, the cohort was divided into two groups depending on whether the patient was mobilized within 0–1 hours (n = 18) or 1–2 hours (n = 119) after arrival in the postoperative recovery unit. Baseline demographics were similar between these two groups except for a lower BMI (median 26, versus 29) and a longer duration of anesthesia (median 4 hours 30 minutes, versus 2 hours 40 minutes) in patients who were mobilized between 1 and 2 hours. For the duration of mobilization, the cohort was divided into three groups depending on if the patient was mobilized <30 minutes (n = 13), for 30 to 90 minutes (n = 50), or >90 minutes (n = 74). Baseline demographics were similar between the three groups.

**Paper III**

In this paper individual face-to-face interviews were conducted with a total of 23 patients recruited from the RCT population who were assigned to either the mobilization and breathing exercises or mobilization only interventions (figure 4). The purposive sample gave 13 women and 10 men, ranging from 38 to 80 years of age with a median age of 65. The majority of the patients, 9 of 23, underwent open abdominal gynecological surgery, 6 of 23 underwent robot assisted laparoscopic cystectomy, 5 of 23 underwent open abdominal surgery and 3 of 23 underwent robot assisted laparoscopic hysterectomy. Nearly 48% of the patients had an ASA physical status score of 3, with a mean duration of anesthesia ranging from 2 hours to 9 hours, and the total sitting time ranging from 20 minutes to 4 hours 10 minutes. The interviews had an average length of 22 minutes.

**Paper IV**

A purposeful sampling of 29 healthcare professionals involved in the mobilization of patients during the RCT (paper I) were identified and asked about attendance in this interview study (figure 4). Twelve (10 anesthesiologists and 2 nurses) declined participation. Even though an extra invitation was sent out to anesthesiologists, none accepted participation due to limited time and to not feeling that they had anything to share from the experience. A total of 17 healthcare professionals were included and participated in individual face-to-face interviews. These included 10 nurses, 3 assistant nurses, and 4 physiotherapists ranging in age from 20 to 59 years, with a median age of 36 years, and all except for one were women. Their experience working with postoperative care was 1 to 28 years, with a median 3 years. The interviews had an average length of 31 minutes.

## 6.2 Immediate mobilization and the impact on respiratory function

The RCT, encompassing Papers I and II, provided findings about the respiratory effect of immediate mobilization in patients undergoing elective open or robot-assisted laparoscopic gynaecological, urological, or endocrinological abdominal surgery. In the ITT analysis (n =

214), patients who received mobilization and breathing exercises improved significantly in $SpO_2$ (MD 2.5%; 95% CI: 0.4 to 4.6; $p = 0.01$) and in $PaO_2$ (MD 1.4 kPa; 95% CI: 0.64 to 2.17; $p = 0.001$) over time compared to the controls. For patients receiving mobilization only, the $SpO_2$ (MD –0.36%; 95% CI: –2.49 to 1.77; $p > 0.99$) did not improve over time compared to the controls, but $PaO_2$ did (MD 0.97 kPa; 95% CI: 0.2 to 1.74; $p = 0.009$) (figure 5a and b). The PP analysis included 201 patients who fulfilled the interventions. For the two intervention groups of mobilization only and mobilization and breathing exercises, the primary outcomes of $SpO_2$ ($p < 0.001$) and $PaO_2$ ($p < 0.001$) increased significantly over time. No such increase was seen for $SpO_2$ ($p = 0.53$) or $PaO_2$ ($p = 0.58$) for the controls (figure 5c and d). $SpO_2$ was significantly improved for mobilization only (MD 2.4%; 95% CI: 1.02 to 3.70) and for mobilization and breathing exercises (MD 2.7%; 95% CI: 1.36 to 4.04) compared to the controls, and $PaO_2$ was improved for mobilization only (MD 1.2 kPa; 95% CI: 0.37 to 2.09) and for mobilization and breathing exercises (MD 1.6 kPa; 95% CI: 0.71 to 2.40) compared to the controls four hours after arrival to the postoperative recovery unit (figure 5c and d). Type of surgery did not influence $SpO_2$ ($p=0.26$) or $PaO_2$ ($p=0.58$).

Preoperative $SpO_2$ was 97.3% (95% CI: 96.7 to 97.9) for mobilization only, 97.2% (95% CI: 96.6 to 97.8) for mobilization and breathing exercises, and 97.5% (95% CI: 96.9 to 98.1) for the controls. Patients in both intervention groups were closer to their mean preoperative values in $SpO_2$ at the fourth hour of mobilization compared to patients in the control group, and these were 95.6% (95% CI: 94.9 to 96.3) for mobilization only, 95.9% (95% CI: 95.2 to 97.7) for mobilization and breathing exercises, and 93.2% (95% CI: 92.4 to 94) for the controls (figure 5c and d).

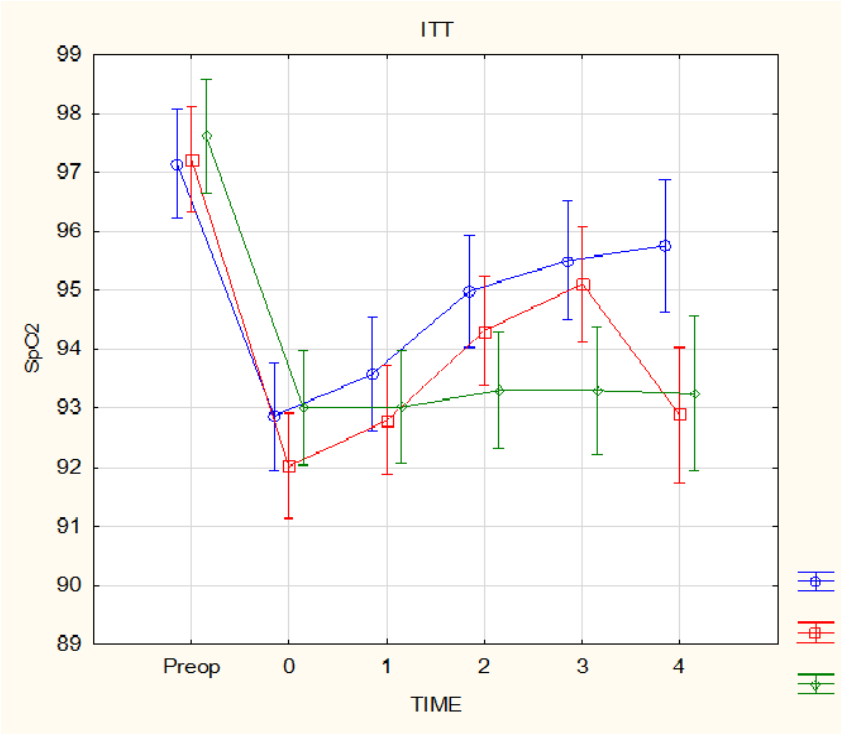


**Figure 5a.**

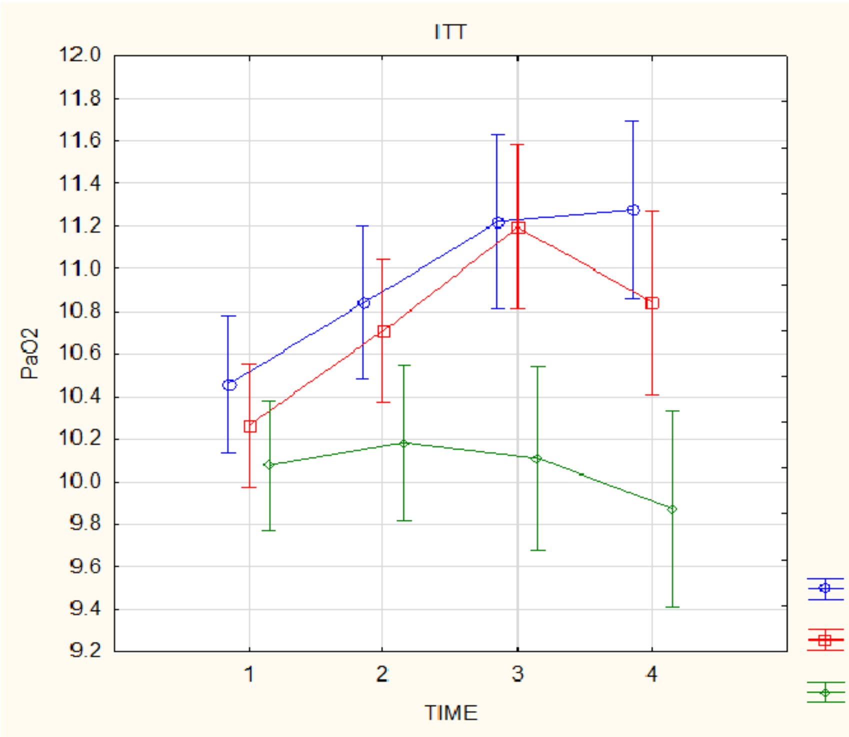


**Figure 5b.**

**Figure 5a and b.** Illustrate the changes in the primary outcomes $SpO_2$ and $PaO_2$ across timepoints, by treatment groups, at 95% confidence intervals in the ITT population (n=214). Blue: Mobilization and breathing exercises (n=73); Red: Mobilization only (n=76); Green: Controls (n=65).

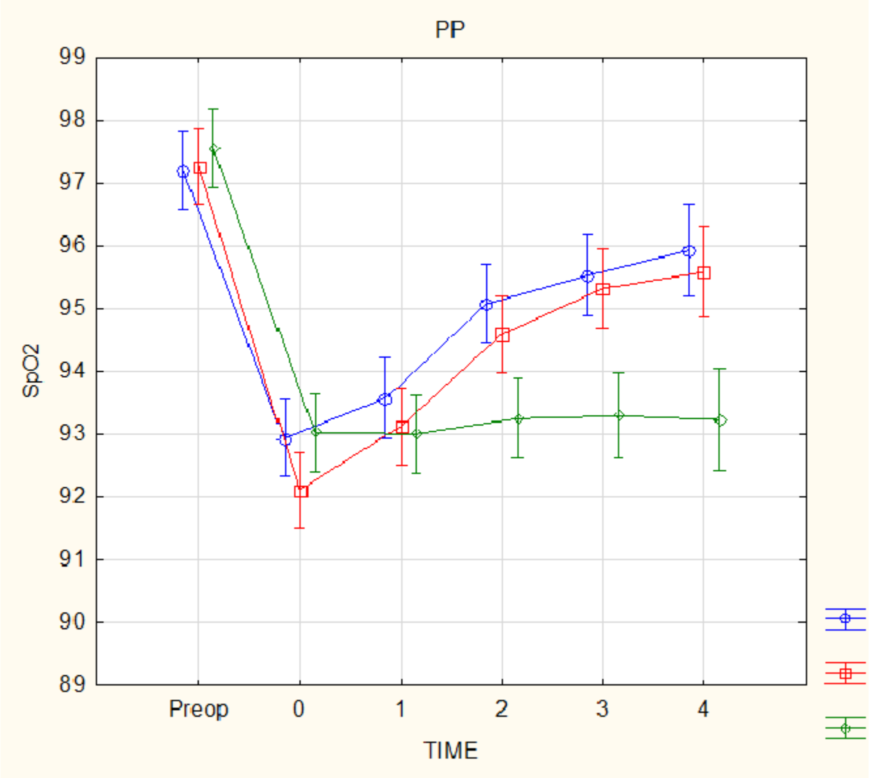


**Figure 5c.**

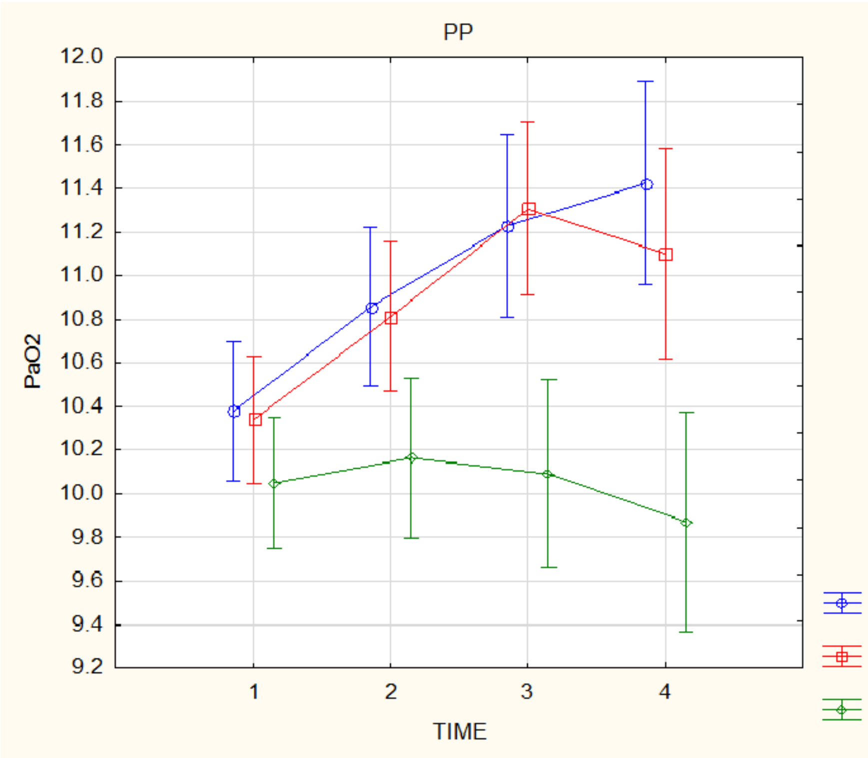


**Figure 5d.**

**Figure 5c and d.** Illustrate the changes in the primary outcomes $SpO_2$ and $PaO_2$ across timepoints, by treatment groups, at 95% confidence intervals in the PP population (n=201). Blue: Mobilization and breathing exercises (n=68); Red: Mobilization only (n=69); Green: Controls (n=64).

For the secondary outcome of $PaCO_2$ and the spirometry outcomes, all three groups decreased over time, with no differences between the groups in the ITT analysis or in the PP analysis. There was insufficient evidence to determine a reduction in risk for respiratory insufficiency or for pneumonia in patients who received mobilization only or mobilization and breathing exercises compared to the controls. Length of stay at the postoperative recovery unit and at the hospital did not differ between the groups. Ratings of pain and nausea were similar between the three groups, and no adverse effects were registered with mobilization.

## 6.3 Mobilization initiation time, duration of mobilization and impact on respiratory function and length of stay at postoperative recovery unit

No differences were found in $SpO_2$, $PaO_2$, or length of stay at the postoperative recovery unit for the 11 patients mobilized within the first hour (mean $SpO_2$ = 94.5% (SD 2.1); mean $PaO_2$ = 10.2 kPa (SD 1.2); mean length of stay = 8 hours (SD 11)) upon arrival in the postoperative recovery unit compared to the 119 patients mobilized within the second hour (mean $SpO_2$ = 94.8% (SD 2.0), mean $PaO_2$ = 10.8 kPa (SD 1.3), mean length of stay = 11 hours (SD 9)) after arrival. There were also no differences in duration of mobilization or $SpO_2$, $PaO_2$, or LOSP. There were no significant differences between the 13 patients mobilized for less than 30 minutes (mean $SpO_2$ = 95.3% (SD 1.7), mean $PaO_2$ = 10.9 kPa (SD 1.4), and mean length of stay = 12 hours (SD 12)) compared to the 50 patients mobilized for 30–90 minutes (mean $SpO_2$ = 94.8% (SD 2.1), mean $PaO_2$ = 10.8 kPa (SD 1.4); mean length of stay = 9 hours (SD 8)) and to the 74 patients who were mobilized for more than 90 minutes (mean $SpO_2$ = 94.6% (SD 2.0), mean $PaO_2$ = 10.7 kPa (SD 1.3), and mean length of stay = 12 hours (SD 9)). After adjustments for potential confounders and time-varying effects, the results remained in the mobilization initiation time analysis and in the duration of mobilization analysis.

## 6.4 Patient experiences of immediate mobilization

From the content analysis of the face-to-face interviews with patients in Paper III, the overarching theme “To do whatever it takes to get home earlier” and the three categories “The impact of mobilization”, “To feel safe and be confident with the mobilization process”, and “Experiences and motivational factors” emerged, as shown in figure 6.

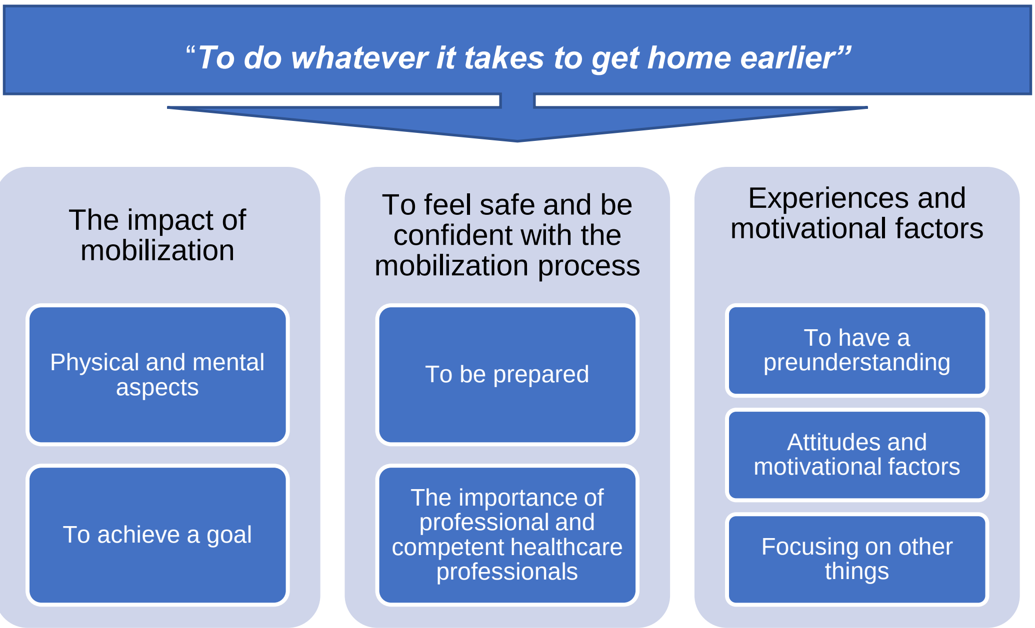


**Figure 6.** The overarching theme, the three categories, and the respective subcategories that emerged in the content analysis of patients' experiences of immediate mobilization after abdominal surgery.

We found that patients appreciated and valued being mobilized out of bed to sit in a chair within 2 hours after elective open or robot-assisted gynecological, urological, or endocrinological abdominal surgery. A patient expressed "*I hoped it would help me even at this stage..that it would speed up my mobilization in general ... and I kind of felt like I had everything to gain and nothing to lose" "* P.21

### 6.4.1 The impact of mobilization

The patients described worries about physical and mental aspects of being mobilized out of bed this early after surgery. Patients experienced it easier to breath and felt hunger and thirst when mobilized and sitting compared to lying in bed. Moreover, they reported that their minds cleared up as they became more alert and oriented. Mobilizing this early was experienced as positive, as they could tick a box because they had achieved a set goal.

*"Yes, it was really nice to sit in that chair; I felt really good"* P13.

### 6.4.2 To feel safe and be confident with the mobilization process

The mobilization procedure was described as being aligned to the patient's feelings of safety and trust based on their own preparedness for the intervention. Information, instructions, and recommendations from healthcare professionals about the mobilization process were important because these created a feeling of preparedness. The patients experienced and expressed that competent healthcare professionals with knowledge in mobilization were important and essential to creating feelings of safety and trust in the patient. Mobilization was possible because competent and alert healthcare professionals were always nearby.

*"... it feels like you are in safe hands! ... I have felt that the people I have met have been competent. They show such empathy"* P.20.

### 6.4.3 Experiences and motivational factors

Patients reported that understanding the physical and mental consequences of mobilization was important. The patients expressed that they were at the same time motivated and unmotivated to mobilize early after surgery. However, they described that they had a fundamentally positive attitude towards physical activity and considered mobilization early after surgery to be a supporting factor for recovery after surgery.

"*I think it would have been worse to stay lying down. Then you would have felt sicker*" P4.

### 6.4.4 Additional results – the gap

The following findings not directly related to the aims of the study emerged in the interviews. Patients expressed that the beneficial effects of the immediate mobilization made them more eager to get out of bed even at the surgical wards. However, some patients experienced a delay in mobilization at the surgical wards because of a lack of pain control and the lack of close-by healthcare professionals in surgical wards compared to the postoperative recovery unit. *"... but there was so much to do that even though I started nagging at seven o'clock I had to wait until half past ten to get up. They did not have time."* P3.

## 6.5 Healthcare professionals´ experiences of immediate mobilization

From the content analysis of the face-to-face interviews with nurses, assistant nurses, and physiotherapists in Paper IV, the overarching theme “A changed mindset” emerged with the two categories “Responsibility for the patient´s well-being” and “Prerequisites and challenges”, as shown in figure 7.

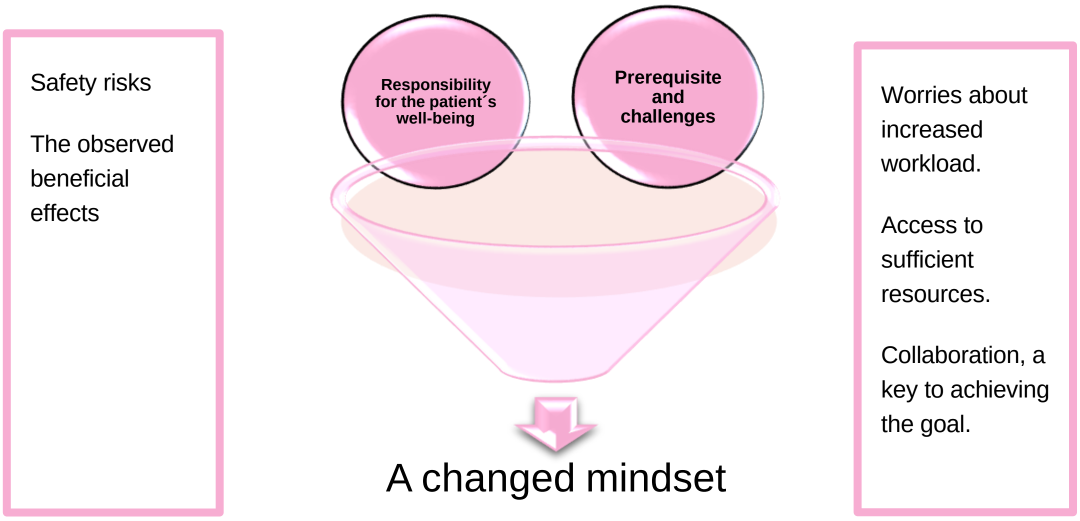


**Figure 7**. An overview of the theme and the subcategories that emerged from the content analysis of healthcare professionals' experiences.

### 6.5.1 Responsibility for the patient´s well-being

Healthcare professionals expressed concerns that mobilization this early after surgery might be harmful for the patients and risk their safety. They based this on the fact that the intervention had not previously been tested.

*"My fears are rather that they will have huge pain breakthroughs. And just this with fainting and drops in blood pressure and so on, but in general these are easily dealt with. It's just that it can be uncomfortable for the patient and difficult for us."* P14.

However, they experienced that mobilization was beneficial for the patients as they became more lucid and regained their autonomy, as one healthcare professional expressed it: *"The patient transformed from being a patient to becoming a human being".* Healthcare professionals described that it was easier for patients to breath and cough while sitting and being able to reduce or disconnect their oxygen supply. Also, the patients seemed to have stable circulatory parameters, and pain was not an obstacle. Healthcare professionals experienced that patients thus were in less need of their care and were ready for discharge earlier. All of this made the healthcare professionals feel satisfied with mobilizing patients already at the postoperative recovery unit. Thus, the healthcare professionals expressed that their previous concerns about safety risks were overshadowed by the observed effects of the immediate mobilization with the patient's well-being in focus.

*"..You were kind of shocked at how alert the patient became, that they actually could…"* P4.

### 6.5.2 Prerequisites and challenges

Initially the healthcare professionals expressed worries for themselves because immediate mobilization was expressed as a new work task in their already full schedule.

*"But there are some things that only a nurse can do. And if you have three other patients who have greater medical requirements, then it may just be extra stress"* P3.

At the same time the healthcare professionals also stated that the postoperative recovery unit is a safe and secure place for the first mobilization after surgery because appropriate equipment, medical knowledge, and surveillance of patients are in place. Moreover, experienced physiotherapists are present until 9 p.m., which was expressed as important because they have knowledge, experience, and training in mobilization. The team and the collaboration within the team and with the patients was expressed as vital and as the cornerstone for a successful mobilization. During the mobilization of a patient, different professions took on different roles and had different responsibilities, thus it was crucial that the entire team was present for a safe mobilization.

*It is golden when you have a physiotherapist who is involved and can provide even more information to us and can support both us and the patient – someone who knows how to move when you are newly operated on so that you do not strain the surgical wound too much"* P13

Collaboration was appreciated because it increased knowledge, competence, and teamwork.

*"Mobilization is important… so everyone has a little goal, yes, but the patient must be mobilized and then, so the patient can go… then it is also a lot of this teamwork, I think, that enables us to make some assessments and to use each other's competences and so on"* P8.

# 7 DISCUSSION

This thesis intended to evaluate the respiratory effects of immediate mobilization during the postoperative period among patients undergoing elective open or robot-assisted laparoscopic gynecological, urological, or endocrinological surgery. It further sought to describe patient and healthcare professionals' experiences of such an early mobilization procedure.

## 7.1 Summary and discussion of the main findings

Immediate mobilization out of bed to sit in a chair within 2 hours after arrival at the postoperative recovery unit seems to improve $SpO_2$ and $PaO_2$. The addition of standardized breathing exercises by use of the PEP technique did not seem to further improve $SpO_2$ and $PaO_2$. No improvements in $SpO_2$ and $PaO_2$ were found in the controls (bedrest). Neither the commencement time nor the duration of mobilization seemed to effect the outcome in terms of $SpO_2$, $PaO_2$, or length of stay at the postoperative recovery unit. The occurrence of respiratory insufficiency during the stay at the postoperative recovery unit and pneumonia within 2 weeks after surgery did not differ between patients assigned to mobilization only, to mobilization and breathing exercises, or to controls (bedrest).

Patients described mobilization already at the postoperative recovery unit as an important part of their care because they experienced that it facilitated and enhanced their physical and mental recovery after surgery. This was important because their main goal was to get home as soon as possible. The patients described that their mind cleared up and it was easier to breath when sitting in a chair compared to being cared for in bed, which was confirmed by the healthcare professionals. Healthcare professionals' initial doubts about mobilizing patients this early after surgery diminished when they experienced that there was no safety risk for the patient, on the contrary it seemed beneficial for physical and mental recovery. To facilitate and accomplish a safe mobilization, the entire team of nurses, assistant nurses, and physiotherapists were considered crucial. Working as a team reduced the workload because each team member knew what to do and acted according to their division of knowledge, competence, and responsibility.

### 7.1.1 The respiratory effect of immediate mobilization

We found that patients being mobilized out of bed to sit in a chair within 2 hours after arrival at the postoperative recovery unit had increased $SpO_2$ and $PaO_2$ compared to the controls. The differences were statistically significant for both intervention groups in the PP analysis, but not for the mobilization only group in the ITT analysis. As far as we know, this is the first published RCT investigating the immediate and isolated effect of mobilization on $SpO_2$ and $PaO_2$ against an untreated control group and in the immediate postoperative period after elective abdominal surgery. Thus, comparable data were difficult to find. In a recent published RCT, 80 patients who underwent open pancreatic surgery were randomized to mobilization within 4 hours after surgery or mobilization the day after surgery (POD 1) (104). Mean mobilization time was only 6 minutes for patients being mobilized on the day of surgery, and most of them were just sitting on edge of the bed, but they improved significantly in $SaO_2/FiO_2$ compared to the group not being mobilized. That study represents a heterogenous cohort based on another type of surgery with a longer duration of surgery and anesthesia and was quite different from the cohort of patients in paper I in the present thesis. Moreover, the time frame for commencing mobilization differed. Still, both studies found improvements in respiratory function with mobilization within 2–4 hours after surgery. The evidence supports the respiratory benefits of mobilizing patients to sit on the edge of the bed or in a chair already at a postoperative recovery unit, instead of lying in bed.

As previously described, mobilization from the supine position in the bed to an upright position out of the bed leads to a gravitational change in the thorax and abdomen. This causes an increase in inspiratory volume and FRC already in a few breaths (20, 27, 30, 99). An FRC superior to closing capacity opens atelectic parts of the lungs, and this subsequently increases the area for gas-exchange and allows redistribution of air, which entails improvements in $SpO_2$ and $PaO_2$ (27, 30, 99). These were the effects we were looking for and which have been described in previous studies where surgical patients were exposed to different positions (96-98, 102, 168). Thus, this is a highly probable physiological explanation for the respiratory improvements we observed in the intervention groups of mobilization only and mobilization and breathing exercises in paper I.

Mobilization interventions were chosen to commence within 2 hours after arrival at the postoperative recovery unit based on the fact that atelectasis formation is the greatest at 2 hours after surgery (41). Thus, a reasonable assumption in relation to our study is that patients who were cared for in bed during the first 6 hours after surgery were more likely to have a reduced FRC and atelectasis compared to those who were mobilized. Assessment of FRC was not possible in the present thesis, but previous studies found that a reduction in FRC correlates to a reduction in $SpO_2$ and $PaO_2$ (98, 99, 169). The controls (bedrest) in paper I had a more or less constant $SpO_2$ at 93% during the trial period, which is considered low compared to their preoperative value of 97%. Moreover, their $PaO_2$ decreased over time, with a mean of 9.8 kPa at the fourth hour compared to 10.5 kPa at arrival to the postoperative recovery unit. On the contrary, both of the intervention groups – mobilization only and mobilization and breathing exercises – improved in $SpO_2$ and $PaO_2$ over time in the PP analysis and were closer to their preoperative $SpO_2$ of 97% (96% for mobilization only and 96% for mobilization and breathing exercises). This must be considered clinically relevant information because all assessments were performed on patients breathing air with no additional oxygenation.

During mechanical ventilation during anesthesia and surgery, the Lachman concept of "open the lung and keep it open" has been applied as a way to counteract atelectasis at induction of anesthesia (170). The meaning of the concept is to keep the lung volume equal or just above the FRC level by use of PEEP to improve gas exchange and to reduce the risk of formation of atelectasis. Thus, if the theory of the concept were to be applied in the postoperative context in patients within a time period of 2 hours after arriving from surgery, an active intervention such as immediate mobilization, to sit or stand, would probably be a beneficial method because those positions most likely will allow instantaneous physiological improvements in FRC as previously described because the atelectatic area perhaps is not yet developed (27, 28, 30, 100, 171). This perhaps allows the lungs to open and to be kept open. Another option might be to add PEP breathing exercises to mobilization because it is prone to increasing FRC and steady state is reached already at 5 to 6 consecutive breaths (86), and it might also reduce the atelectatic area (84, 88, 90). However, in paper I, we found no additional effects of breathing exercises with mobilization in the PP analysis involving only those who fulfilled the allocated interventions. A possible explanation for the fact that there are no major differences in respiratory outcome between mobilization only and mobilization and breathing exercises may be that the mobilization itself led to the alveoli being already open and being kept open. Still, this does not rule out any effect of the PEP breathing exercises because they might be effective in other cohorts of patients undergoing other types of surgery than those in paper I. Further investigations in the matter are recommended.

With the positive respiratory effects seen with mobilization, the questions remained as to whether the time at which mobilization is commenced and whether the duration of mobilization mattered for $SpO_2$ and $PaO_2$. When this was investigated in paper II, no differences in $SpO_2$, $PaO_2$, or length of stay at the postoperative recovery unit were found in patients being mobilized within the first or within the second hour after arrival at the recovery unit. Nor did mobilization for more than 90 minutes seem to be superior to mobilization between 30 to 90 minutes or for less than 30 minutes. This implies that the respiratory effect of mobilization is irrespective of initiation time and duration, given the investigated time frames in this study. Another explanation may be that the FRC as well as atelectatic area were actually equal between the mobilization initiation groups and also between the duration of mobilization groups, reflecting the similarities in $SpO_2$ and $PaO_2$. This is based on the previous assumption that mobilization within 2 hours after surgery might reduce the risk for collapsed airways and reduce the formation of atelectasis, and this supports the importance of "open the lung and keep it open" within this time frame because ventilation and perfusion in the lungs is greater in open lungs compared to lungs with collapsed airways and atelectasis (30, 34, 36, 97, 98, 100, 101). However, it is also possible that the time frame was too short and the groups too small to detect reliable differences. Even though adjustments for potential confounders were applied after discussion and according to reference literature, we might have missed out on potential confounders because this is the first study on the subject (172). Nevertheless, a short mobilization to stand or sit in a chair already at the postoperative recovery unit might still be favored compared to bedrest.

Nevertheless, bedrest is associated with increased risk of postoperative complications, and thus is not a recommended treatment after surgery (1, 2, 173). This is important to take into consideration because most patients after extensive surgery, with an increased risk of PPC, arrive at the postoperative recovery unit in the afternoon or evening. Thus, given the results in paper I, by just allowing these patients to sit at bedside, stand for a while, or move to a chair already at the postoperative recovery unit, instead of being cared in bed until the day after surgery, might improve $SpO_2$ and $PaO_2$ and reduce the risk for atelectasis. This is not least given that reduced or low $SpO_2$ and $PaO_2$ are usually initially treated symptomatically by the addition of extra oxygen up to a satisfactory level of $SpO_2$, but this only "masks the problem" and does not prevent, treat, or solve issues related to atelectasis or other PPC.

Consequently, the optimal commencement of mobilization is not yet certain, but it might be important to start within the time frame of 2 hours after surgery due to the development of atelectasis in combination with the improvements in $SpO_2$ and $PaO_2$ we found in patients who were mobilized in paper I (41). Still, most studies in the area of mobilization after abdominal surgery are conducted on the day after surgery (105, 112), and some use mobilization mixed with physiotherapy interventions (91, 113). Their rather vague results for these interventions on respiratory function might thus be reduced due to the fact that atelectasis is already established (41, 43). Moreover, there is still no evidence for optimal duration of mobilization. However, the most important message is perhaps just to mobilize, and preferably within the time frame of 2 hours, because the instantaneous respiratory effect of the mobilization might be of superior importance (34, 36). Thus, mobilization should be suggested as the first choice of method to increase FRC, $SpO_2$, and $PaO_2$ immediately after surgery as a way to reduce the risk of atelectatic areas. Thus, to "open the lung and keep it open" by use of the quite simple intervention of immediate mobilization might be crucial for the patients.

The improvements in $SpO_2$ and $PaO_2$ were not only visible during the measurements in the quantitative studies (paper I), the respiratory effects of mobilization were also experienced by the patients and the healthcare professionals in the qualitative studies (papers III and IV). The patients described that it was easier to breathe when they sat in a chair compared to when they were lying in bed, which was confirmed also by the healthcare professionals. In addition, the healthcare professionals indicated that oxygen could be reduced or even disconnected at an earlier stage in patients who were mobilized to sitting in a chair, although the latter was not controlled for in any of our studies. However, a similar study of pancreatic patients found that those who were mobilized on the day of surgery had a reduced need for oxygen already on the day after surgery and still on the day after surgery compared to controls not mobilized until the day after surgery (104).

No differences were found between the intervention groups and the controls in paper I (ITT-analysis) in terms of pneumonia. However, after discharge from the postoperative recovery unit, we had no control over continued treatments in the form of breathing exercises or mobilization that the patient was likely to receive in the surgical ward and that are likely to have diluted the actual effect of the mobilization interventions at the postoperative recovery unit and the incidence of pneumonia. Moreover, as confirmed by other studies, the type of surgery in regards to open or laparoscopic surgery did not influence the outcome in terms of $SpO_2$ and $PaO_2$ (25, 26). An assumption is that the included cohort of patients irrespective of type of surgery, duration, and surgical position responded similarly to the mobilization interventions. However, further studies on the subject are needed.

### 7.1.2 The patients´ and healthcare professionals' experiences of immediate mobilization

The patients stated that the presence of competent healthcare professionals was important to them during the mobilization because it made them feel confident and secure, and this is similar what has been emphasized by patients in other studies (132, 133, 136). Patients may feel vulnerable in the immediate phase after surgery but having healthcare professionals nearby who can support them mentally and physically with medication, assistance, mobilization, or just someone to talk to might help reduce anxiety and worry. To actively participate in one's own care, recovery, and mobilization has been proven to be motivating for patients and might also reduce anxiety and worries because one's focus is elsewhere, and this was confirmed by the patients in paper III (131, 134, 135, 174). Kalish et al. (7) investigated outcomes of inpatient mobilization and found that patients mobilized at an early stage seemed to become independent in their mobilization earlier than those who did not mobilize. Moreover, mobilization not only had a positive impact on physical functions, but also on emotional and social well-being, and depression and anxiety decreased, and satisfaction increased (7). These results support our findings in papers III and IV where patients expressed that they appreciated being mobilized already at the postoperative recovery unit and healthcare professionals told how patients regained their autonomy and thus were more satisfied. The patients in our study were highly motivated by the fact that mobilization this early after surgery might facilitate their mobilization in general and enhance their recovery because going home as soon as possible was their main goal. Moreover, the surgical wards reported to the healthcare professionals that patients being mobilized at the recovery unit were keen to mobilize also at the surgical wards, and thus they took active responsibility for their own care. This information seems to support mobilization of patients already at the postoperative recovery unit, especially the latter observation, because we did not actively seek for information about how the surgical wards responded to patients being mobilized this early and this only emerged during the interviews with the healthcare professionals.

Safety aspects such as fear of pain, nausea, and strain on wounds as well as risk of circulatory issues/hemodynamic instability, fatigue, and dizziness have been reported as barriers and hindrances to mobilization by healthcare professionals as well as patients irrespective of whether the patients are mobilized at surgical wards or at intensive care (117, 125, 126, 133, 175). The same aspects and worries were brought up by healthcare professionals and patients in papers III and IV. Healthcare professionals were aware of the physical effects of mobilization but stated that the immediate mobilization intervention was new to them and not tested before, and therefore they were initially a bit skeptical. The patients appeared less skeptical than the healthcare professionals, perhaps because, as they themselves expressed, they trusted the healthcare professionals to do their utmost for the patient's well-being. However, the worries changed when the physical and mental effects of mobilization appeared for both perspectives. This seems quite reasonable because both healthcare professionals and patients were shown that mobilization this early after surgery worked, was feasible, and was beneficial for the patient, not the opposite.

Although patients and healthcare professionals had expressed worries about pain and nausea during mobilization, these were experienced as manageable and not seen an obstacle for mobilization. Ni et al. (109) found that patients allocated to mobilization starting at POD 1 after liver resection seemed to have less pain and anxiety compared to those who were allocated standard care. A previous Swedish study found little or no pain and nausea during the postoperative period in patients who underwent laparoscopic cholecystectomy (176). One can, however, speculate whether it is the combination of adequate pain and nausea relief and monitoring by experienced, trained staff (nurses and assistant nurses) in combination with mobilization that takes place in a correct way with the support of experienced, trained staff (physiotherapists) that can explain why pain, nausea, circulatory issues, and hemodynamic instability were not considered as problems by either healthcare professionals or patients. This is especially likely considering that data from paper I indicate that the intervention groups (mobilization only and mobilization and breathing exercises) did not differ in ratings of pain and nausea compared to the controls. By always having healthcare professionals in close proximity while at the postoperative recovery unit, pain, nausea, and respiratory and circulatory issues/hemodynamic instability are continuously and closely monitored and thus always handled promptly because the healthcare professionals at the postoperative recovery unit possess the necessary medical competence and have experience in dealing with these problems (177).

As patient care has become increasingly complex, the need for specialized health professionals has increased (178). Moreover, adequate resources, training, and multidisciplinary collaboration has been addressed as important for the successful postoperative care of patients after surgery (177), and a lack of these has been suggested to be a barrier for improvement in postoperative outcome and mobilization (70, 118, 119, 121, 125, 127, 133). Multidisciplinary collaboration has been emphasized and recommended as important to improve patient treatment and recovery, not only by healthcare professionals and patients in our interview studies and in other studies (133, 138, 177-180), but also by the World Health Organization (181). Patients as well as healthcare professionals in papers III and IV stated the importance of having the entire team represented and present during the mobilization. Patients perceived that it made them feel safe and confident with the mobilization process because they then felt that they were professionally guided through the entire process, as confirmed in other studies (7, 132-134). Healthcare professionals stated that working as a team helped them understand the importance of their different perspectives during the mobilization, and they gained and exchanged knowledge. This has been brought up as one of the most important benefit of interdisciplinary learning and of working as a multidisciplinary group (178). Moreover, they appreciated that they performed slightly different tasks during the mobilization. In this way, the skills of the entire team were used, which ultimately freed up their time. Consequently, their concern that the immediate mobilization would lead to an increased workload decreased. During the time of the randomized controlled study (paper I), the physiotherapist was available at the postoperative recovery unit between 9 a.m. and 9 p.m. Thus, nurses and assistant nurses were supported by and worked in a team together with a profession with specific education, skills, experience, and training in mobilizing critically ill patients (182). To have that competence available even outside office hours was highly appreciated by the other staff and by the patients, mainly because both healthcare professionals and patients perceived the physiotherapist as the leader and initiator of the mobilization of patients after abdominal surgery. Having the overall competence in place enables teamwork (138, 178, 180). When it comes to facilitating the mobilization of critically ill patients or patients who have undergone surgery, teamwork has been shown to be extremely important because different professions make different assessments of a patient's ability to be mobilized (118, 138, 179). Compared to nurses and medical doctors, physiotherapists appear to initiate mobilization more frequently and are keener to mobilize critically ill patients and at a higher level (183). This may be because different professions have different perspectives on mobilization. Physiotherapists work according to a holistic approach with an aim to promote health and to maintain or regain optimal mobility and movement in function as a way to achieve health and quality of life (182). Hence, the physiotherapist makes an assessment of each individual's ability and prerequisites for mobilization (184), which may explain the physiotherapist's attitude toward mobilization. Nevertheless, as stated by the healthcare professionals themselves, the entire team is needed for a safe immediate mobilization.

In the framework of the results in the quantitative and qualitative studies presented in this thesis, the postoperative recovery unit seems to not only be a place for recovery, but it also seems to be a well-situated place for initiating of mobilization of patients, as stated by the healthcare professionals and the patients. However, it is important that the entire team is present when the patients enter the unit after elective surgery irrespective of whether it is in the afternoon or in the evening.

A strength of this thesis is that the results are based on quantitative objective measures and qualitative experiences. When combining these, the entire perspective of immediate mobilization is visible, not only at the micro perspective of $SpO_2$ and $PaO_2$, but also at the macro perspective of describing mobilization as a means to an end in the form of facilitated recovery to be able to return home.

### 7.1.3 Theoretical application of the movement continuum theory

As described in the background, there is a gap between current and preferred physical capacity in patients after surgery (139). Cott et al. described the movement along the continuum as a dynamic and independent process (139). Thus, in the context of this thesis the micro to the macro perspective implies the impact of the immediate mobilization on muscular and respiratory cells, the muscles, the lungs, and respiratory function and gas-exchange and its impact on the physical and mental systems by sitting, becoming alert, facilitating autonomy, and being able to mobilize independently. Through cooperation, support, and motivation from healthcare professionals along with expectations and motivation in the patient themself, the patient might start mobilizing already at the postoperative recovery unit, thus enhancing their recovery and their ability to be discharged from the hospital. Thus, mobilization immediately after surgery might facilitate movement along the continuum from the micro to the macro level, from the current, impaired level to the preferred capacity. Thus, immediate mobilization should be applied in all patients as soon as possible after surgery instead of being cared in bed until the day after surgery.

## 7.1 Methodological considerations

Because this thesis represents studies with diverse designs and methodologies, interpretations of the results have to be made in regards to methodological considerations.

### 7.1.2 Internal and external validity - Papers I and II

A strength of the intervention study (paper I) is the RCT with an untreated control group.

*Selection bias and randomization*

The population of open or robot-assisted laparoscopic elective gynecological, urological, and endocrinological patients was consecutively included by a person with no other involvement in the study and not involved in the randomization. Block randomization was chosen to dilute the risk of a skewed distribution of patients to intervention groups at the same time at the postoperative recovery unit. Randomization rendered three relatively similar groups at baseline, except for age and ASA classification. A stratification of patients might have rendered a more evenly distribution of patients (185). Baseline characteristics were, however, adjusted in the analysis. The risk for selection bias might therefore be reduced. However, patients were excluded if they required assistance for mobilization prior to surgery or if they were not able to understand instructions or if they arrived at the postoperative recovery unit after 6 p.m. Even if the number of patients excluded was small, there is a risk for selection bias and we may possibly have missed data from important subgroups.

*Attrition bias*

Loss to follow up and missing outcome data in RCTs can risk over- or underestimation of treatment effects (186). In paper I, a total 13 patients (6%) discontinued the protocol, unfortunately unequally distributed per study group (five in the mobilization and breathing exercises group, seven in the mobilization only group, and one in the controls). Still, this might be considered as a quite small number when it comes to risk for attrition bias because the rule of thumb is that more than 20% is a threat to validity (155). Reasons for discontinuing the protocol per study group was presented in the consort flow chart as recommended, and baseline characteristics were presented in a demographics table, which is to be considered a strength with regards to transparency of data (185, 186). Six patients in the intervention groups discontinued the protocol because of medical reasons, but none in the control group discontinued due to medical reasons. It is possible that those patients differed in patient characteristics compared to those who received the allocated interventions. A recommended way to handle the scenario of loss to follow-up is to perform ITT analysis because this includes all randomized patients, reflects the true clinical scenario, and maintains the sample size (187). By just presenting the PP analysis the results can be interpreted as too optimistic and thus have a risk of bias (187). According to recommendations for RCTs, ITT and PP analysis were thus applied and presented for transparency and generalizability of the data (155, 185, 186). The differences between ITT and PP analyses in paper I were not so great, thus the impact of the loss to follow-up may not have been so critical for the outcome.

Another consequence of discontinuing the protocol is missing data, which might have reduced the power of the $SpO_2$, $PaO_2$, and $PaCO_2$ analyses. However, linear mixed model analysis was used. This model is recommended because it is less sensitive to at-random missing data compared to analysis of variance where least-square solutions are used to calculate missing data. The linear mixed model instead uses a maximum likelihood solution for the remaining data (151, 152).

*Misclassification*

Because paper II was a secondary analysis of the data from paper I, the included patients were those who received interventions in paper I. The two intervention groups did not differ at baseline. However, during the analysis they were divided into groups based on clinical relevance, and the risk of misclassification bias and incorrect conclusions due to an inaccurate case definition cannot be ruled out (172, 188).

*Measurements*

In papers I and II, the outcome measures, instruments, and procedures were standardized at each assessment to increase the validity and reliability (189). Even so, there might be limitations to the different instruments used for the assessments (189). For peripheral $SpO_2$, a measurement variability of up to ±2% has been reported, and factors such as motion artefacts, being cold, and use of nail polish can adversely affect reliability (147, 190). $PaO_2$, as assessed via an arterial blood gas sample, is considered to be a more robust objective measurement compared to peripheral $SpO_2$ (147, 148). To reduce the risk of measurement errors and to increase reliability, the blood samples were analyzed immediately and in the same regularly calibrated machine (22, 148).

The spirometry was performed according to standardized recommendations by the same few persons (a research nurse and physiotherapist) because consistency in the position of the patient and the instructions for how to perform the procedure has been shown to increase reliability (149). Abdominal surgery within 4 weeks is included as a relative contraindication for spirometry in the recently published guidelines (149). Although we ensured that the patients did not report pain before performing spirometry, there are still concerns that the abdominal incision or the fear of spirometry causing pain might have impaired the patient's ability to perform correct spirometry on the day after surgery. As found also in a previous study, spirometry values are decreased in patients the day after surgery (191, 192).

Several factors have an impact on total length of stay at the postoperative recovery unit, and we did not control for those, which is a limitation. Another approach based on readiness for discharge with regards to respiratory and circulatory stability and pain control would have been preferred to obtain an objective measurement.

*External validity*

Usually, RCTs are criticized for having an overly homogeneous group, which generally means that it is difficult to generalize the results to other groups, situations, and contexts not reminiscent of the tested cohort of patients (185). This RCT presented quite the contrary, a heterogenous population, and thus the generalizability might be considered somewhat better. Still, the possibility of generalizing the results is also dependent on how well the cohort of patients, setting, and the context are described (185). This thesis presents data from a university hospital, and thus was a single center study. A university hospital is assigned with performing highly specialized care, often on seriously ill patients with several comorbidities. The present thesis might thus be questioned in regards to generalizability because the population perhaps is not representative of other populations at other hospitals in terms of type of surgery, duration of anesthesia, and potential risk of postoperative pulmonary complications. Still, significant improvements in $SpO_2$ and $PaO_2$ were found in patients who received the mobilization interventions in the RCT compared to the controls, and applying immediate mobilization in another cohort of patients might possibly render the same improvements in respiratory outcomes as presented in this trial. Accordingly, we suggest future studies to include patients undergoing other types of surgery.

### 7.1.3 Trustworthiness - Papers III and IV

For both papers a qualitative design with semi-structured face-to-face interviews and content analysis was chosen to answer the research question.

Throughout the entire process of a qualitative study, from preparation, to organization, to publication, it is important to assure and increase credibility, dependability, transferability, and conformability to establish trustworthiness (142, 161). To ensure credibility, the data were initially coded by the author of this thesis and also independently by the last author of each qualitative paper (MN-B for paper III and AS for paper IV), then the coded data were compared for discussion of differences and similarities (161). All authors were involved in the data analysis, and investigator triangulation was used to confirm and/or to discuss the findings (142, 161). Member-check was done during the interviews when the informants regularly summarized what they had said. In addition, the data in paper IV were confirmed as the findings were presented for the healthcare professionals at a meeting. In the reporting phase, in order to stay manifest and keep the core of the text, the codes and subcategories were named using content-characteristic words, which can also be seen as a way to increase the reliability of the findings (159, 160).

The analysis process was iterative, and to keep track of decisions in the coding process and other changes during the process, memos were used by the author of this thesis as a way to maintain the stability of the data over time and to increase dependability (142, 161). The data collection period was quite stable as the interview took place during a relatively short period of time in both studies, and the circumstances as well as interventions were quite similar during the study period. Still, some patients reported that it was difficult to recall the mobilization intervention at the postoperative recovery unit (paper III). The semi-structured guide was tested during a pilot interview, then slightly changed to obtain more probing questions (145). The quality of the data from the interviews was considered satisfactory because they were rich, provided a broad perspective, and answered the research questions, although some interviews were short. The data collection ended when nothing notably new related to the research question emerged, and the decision to end the data collection was made in consultation with the interviewers in each study. The research group represented different professions that specialized in different areas of critical and surgical care, thus with different experiences of mobilizing patients who have undergone surgery. This can be considered to contribute to an in-depth as well as broadened and enriched analysis of the data (161, 193).

The findings from papers III and IV might be transferable to similar contexts of patients, healthcare professionals, surgeries, and environments, and thus it is important to be transparent in the description of the setting, context, cohort, and methods used for analysis. In papers III and IV, we chose a purposeful sampling of patients (paper III) and healthcare professionals (paper IV) in order to attain a broad variation of experiences of the phenomenon being investigated (142). Moreover, we provided a clear description of the methods and analysis. Whether our work is transferable to other settings or contexts is up to the reader or researcher to judge (194, 195).

The methods, the semi-structured interview guide, and the analysis and results were presented thoroughly in text to validate our findings and were reinforced with citations and tables for exemplifying the data analysis in order to allow transparency of the analysis and to strengthen the conformability the studies (142, 159-162).

### Ethical considerations

For paper I, it can be questioned if it was ethically appropriate to use bed-bound controls, not receiving any mobilization or breathing exercises during the time frame of 6 hours (or earlier if discharged). Moreover, we chose to disconnect oxygen in the regular assessments of $SpO_2$, $PaO_2$, and $PaCO_2$. The reason for this was to allow for comparison of data over time within and between groups and to investigate the true respiratory insufficiency in patients. Another alternative could have been to maintain the supply of oxygen and instead calculate $PaO_2$ kPa/FiO2 % (PFI), i.e., the ratio between the oxygen pressure in arterial blood ($PaO_2$) and the proportion of oxygen in inhaled air, for those with arterial needles (22). However, postoperative respiratory insufficiency is not yet defined according to PFI and therefore it is difficult to compare to reference values (51). However, during the planning of the study the safety of the patients was considered and was worked through in consultation with the anaesthesiologist in charge of the postoperative recovery unit. The criterion for exclusion due to circulatory and/or respiratory problems was set up and was evaluated by an anaesthesiologist if present during the trial. Consequently, the safety criteria were decided prior to seeking ethical approvals and thus prior to start of the RCT (paper I).

# 8 CLINICAL IMPLICATIONS

The findings of this thesis have several clinical implications, especially as it adds new knowledge to the field of mobilization after elective abdominal surgery. It covers all complex interactions in different organ systems in the body that need to function after surgery in order to bring about as optimal recovery as possible for the patient.

Based on the findings in the thesis, immediate mobilization after elective abdominal surgery is important and beneficial for the patient's physical and mental well-being and should therefore continue to be recommended. However, a recommendation (by the surgeon in charge, or as in the ERAS concept) about mobilization as early as possible after surgery is not enough for the mobilization to take place. It is also not enough that the healthcare professionals have a positive attitude towards immediate mobilization. If we are to implement this method, there is a need for structural changes, for clear clinical guidelines and policy documents to be written, routines to be trained and processes that work invoked. Otherwise, there is a risk that patients will be just monitored in bed- and mobilization after surgery will be postponed to the day after surgery.

Postoperative care should not only involve monitoring of circulation, pain and fluid balance, but also testing that the patient can get up to sitting and standing ensuring optimization before discharge to the surgical department. Thus, mobilizing patients already at the postoperative recovery unit can be seen as a way to enhance the patient’s respiratory status, facilitate autonomy, and to increase alertness.

The healthcare professionals´ and the patients´ interviewed for this thesis reported that they found immediate mobilization to be safe and the postoperative unit a well-situated place for first mobilization after surgery. However, need was expressed for the entire team of nurses, assistant nurses and physiotherapists to be available in afternoons and evenings, to coincide with the arrival of the majority of patients, especially those going through extensive surgeries. Accordingly, a different scheduling of staff is likely to be required. A dedicated mobilization team would potentially be of interest to facilitate immediate mobilization.

# 9 CONCLUSIONS

The combination of quantitative and qualitative research was chosen to explore not only the respiratory effect of immediate mobilization (macro level), but also to gain insight into how patients´ and healthcare professionals´ experience mobilization. The goal was to shed light on the parts of the immediate postoperative care that can contribute to an improved recovery for patients who have undergone elective open or robot-assisted laparoscopic gynecological, urological, and endocrinological abdominal surgery. Thus, by mobilizing patients this early after surgery, the gap between current physical and preferred capability might be reduced more quickly. This thesis has contributed to an overall understanding of both objective and subjective aspects:

- Patients who were mobilized out of bed within 2 hours after elective abdominal surgery improved in terms of $SpO_2$ and $PaO_2$ compared to those who had bedrest.
- It seems that mobilization per se is the most important for improvements in $SpO_2$ and $PaO_2$ after these types of surgeries because mobilization within the first hour after surgery was not inferior to mobilization within the second hour. A prolonged duration of mobilization (over 90 minutes) did not seem to surpass a shorter period (30 to 90 minutes or less than 30 minutes) because improvements in SpO2 and PaO2 were similar in all patients.
- Immediate mobilization was valued by the patients because they experienced it had a positive effect on their overall wellbeing, mentally as well as physically. Thus expressed as a motivating factor and an important part of the postoperative care. Patients experienced they had everything to win and nothing to lose by this early mobilization because their main goal was to go home.
- When healthcare professionals observed the positive physical and mental effects of patients with immediate mobilization, their initial ambiguous feelings changed to the belief that immediate mobilization improved and favored patients' recovery.
- The postoperative recovery unit was experienced as a safe and and well-situated place for first mobilization after surgery by patients and by healthcare professionals. Further to work together as a team, was experienced as important to facilitate immeidate mobilization.

# 10 FUTURE RESEARCH

To further understand, investigate, and determine the respiratory effects of mobilization within the postoperative phase, further research is needed. The present thesis involved patients who had undergone elective gynecological, urological, and endocrinological open or robot-assisted laparoscopic abdominal surgery at a single center. RCTs including multiple centers and other types of surgery are needed to further investigate and determine the impact of immediate mobilization on respiratory function. Such studies will allow for scaled-up subgroup analysis thus making it possible to investigate whether any or some patient categories or types of surgery gain more or less from the intervention. Moreover, it seems important to extend the follow up period and evaluate the need for oxygen the day after surgery for patients with immediate mobilization.

In the present thesis we got a small glimpse of patients' and healthcare professionals´ experiences of mobilization. It is important that future studies explore and then involve the perspective of the patients, the healthcare professionals, and the organization in regards to mobilization in the early phase after surgery because there is still a lack of knowledge in this field. Only then it will be possible to identify barriers and opportunities in the matter and only then will implementation of mobilization immediately after surgery be feasible.

A knowledge-gap still remains with regards to when mobilization should commence after elective abdominal surgery and the duration of mobilization in relation to a favorable respiratory outcome. Powered trials, randomizing patients to groups with wider time frames regarding commence of mobilization and scaling up the total time of being mobilized is recommended.

Although early mobilization after abdominal surgery is recommended, there is still a lack of knowledge as to whether the recommendations are really followed. There is a need for multicenter observational studies investigating if and when patients are mobilized after elective and acute abdominal surgery and if lack of or a late mobilization is associated with impaired respiratory function.

Furthermore, studies should evaluate the cost-effectiveness of the immediate mobilization method applied at the postoperative recovery unit in a health-economic perspective for patients and healthcare professionals.

# 11 ACKNOWLEDGEMENTS

First of all, I would like to express my gratitude to all the **patients** and the **healthcare professionals** who have participated in the studies. Without you, this would really never have been possible.

Supervisors and mentor, my team, the brains. Supervisors and mentor, my brilliant team, the brains. Thank you all for pushing me forward, encouraging and believing in me during these years and making sure that I have sharpened my mind. You all complement each other, and you all inspire me in different ways. I look forward to continued collaborations with you, in one way or another.

**Malin Nygren-Bonnier**, “the social genius”. It has felt reassuring to have you by my side when the going has been tough. Your social intelligence has paved the way. (When I have sometimes felt “thrown to the lions”, you have saved me.) I don’t know how you make it, but you have always made room for me and my questions in your tight schedule. From Lund to Stockholm, the circle is complete.

**Monika Fagevik Olsén**, “the source of knowledge and wisdom” in the research field. How I will miss the annual writing week at Tjörn, where I, among other things, was introduced to, Nisse and Nasse, eat as many cakes as you want for 35 SEK in Skärhamn, and the pre-taste of Easter herring. But most of all, I will miss our in-depth discussions on respiratory physiology - I hope we can continue with them.

**Anna Schandl**, “the master at shortening texts” and a brilliant researcher. You have always had time to guide me in statistical and methodological challenges, to just calmly listen and then give feedback. I've learned a lot .. I can 't express enough gratitude for that.

**Agneta Ståhle**, “the experience”. From ethical and methodological considerations to discussions about clinical research you share your rich experience. We will from now on share the same dissertation date.

**Cecilia Fridén**, my mentor, who gave me realistic perspectives on what really matters.

Thank you co-authors, **Maria Hagströmer**, for contributing with wise perspectives over the years. **Ulrika Holdar**, for your positive energy, always fun discussions, and lots of laughter.

Collaborators thank you: **Ellen Sundqvist** for invaluable help with data collection. **Karin Balbaki** who worked the morning shift in the postoperative recovery unit.

Thanks to the Function Perioperative medicine and Intensive Care (PMI) at Karolinska University Hospital Solna, Medical Unit Perioperative Medicine, Solna with the head of the medical unit **Caroline Hällsjö Sander** who made data collection at the postoperative recovery unit possible and the research nurses **Anna, Anna, Ola** and “**Lisa”** for assisting with data collection. Then I want to thank **all the nurses, assistant nurses, anesthesiologists, surgeons and physiotherapists at the postoperative recovery unit, the preoperative**

**anesthesia clinic, and the surgical departments** for being involved and in various ways participated in data collection of the studies in this thesis.

The research in the present thesis was funded by the **Doctoral school of Health Care Sciences** at Karolinska Institutet, the **Åke Wiberg Foundation** and the **Swedish Research Council**. Thank you for making this doctoral project possible.

To the **Division of Physiotherapy, at Karolinska Institutet** the past and present heads and deputy heads: **Malin Nygren-Bonnier, Nina Brodin, Maria Hagströmer, Joanna Kvist and Annette Heijne**, for the opportunity to undertake my doctoral education at Karolinska Institutet. To **Martina Bergenroth, Kathrin Dellblad and Ellinor Nordström** for invaluable help over the years.

Thanks to all members of the **research group** Function and Health in Respiratory and Cardiovascular Conditions, especially to **Kirsti Skavberg Roaldsen, Alexandra Halvarsson, Malin Sellberg, Pernilla Sönnerfors** who have contributed to interesting discussions and exchange of experiences.

Thanks to all **former and present doctoral students**, for inspiring conversations and support along the way, **Andrea, Sanna, Emelie, Elena, Hanna, Sebastian, Andreas, Tobias, Roman, Carro, Pernilla, Malin and Jenny D**, just to mention a few.

**Past and present colleagues, section managers and heads of the Medical Unit Occupational Therapy and Physiotherapy at Karolinska University Hospital** for encouragement and the opportunity to undertake the doctoral education. Colleagues**, my fellow physiotherapists at NKS**, **former Karolinska University Hospital in Solna, Fredrik, “Mia”, Fernanda, Lisa, Ulrika, Ellen, Frances, Johan**. Thank you for your support and trust and for helping and guiding me when I have been away from the clinic for too long. **Frances**, I also thank you for always taking the time to answer when I text words or phrases in English that I feel unsure of.

**Friends from now and then**, thank you so much for always being there, even though I have sometimes been a little absent for the past four years. Thank you for joy and laughter in life and for helping me see the sun between the clouds. **Ninna, Malin, Sara**, the “Lunda-gang”, thank you for wonderful and crazy trips by night train to meeting up at Stortorget, sharing life during long-night talks. **Ninna** and **Irma** you both challenge and expand my brain and thus also my heart. **Ann, Ulrika, Cajsa, Annika, Anna** “Blekinge-gänget” – jag är samma Raskh, oroa er inte. Jag längtar efter att träffa er alla i Blekinge igen på galet skrattiga middagar, må det bli denna sommar. **Nina**, bästa kusin och vän, jag längtar efter långpromenader i Snärjets bokskog och lugnet i kvarnstugan, kanske också lite pang-pang-bio. **Sofia,** for recaptured friendship and creative conversations about "the continuum". **Cicci**, för din positiva energi. **Malinkan,** för att du alltid bjuder på den bästa musiken och de stora skratten. Thank you all for big and small conversations about life.

**Family**

**Mamma**, vad och vart hade jag varit utan dig. Tack för att du alltid har orkat kämpa! Tack för all god mat (förmiddags- och eftermiddagsfika) och för att du ALLTID har funnits där när jag har behövt ditt stöd och för att du alltid har lyssnat. Tack för att jag fick komma ner för att skriva och tanka kraft från bokskogen och löprundorna längs Mörrumsån. Du är en trygg hamn.

**Karolina**, kära syster, du är så lugn och klok, vilket är skönt när jag är uppvarvad. Det är så fint att få dela erfarenheter igenom livet med dig. Tack för att du och din fina familj alltid finns nära. Så mycket skratt och så mycket glädje att få vara moster till er **Ellie och Edith.** **Fredrik**, kära bror, så härligt att ha dig nära igen.

**Ylva**, tack för pepp och all hjälp genom åren med stort och smått. Det är roligt och berikande att umgås med dig.

**Stefan**, the love of my life. Tack från djupet av mitt hjärta för att du alltid finns där, du lyssnar och stöttar, påminner mig att äta och träna och hjälper mig med datorkrångel. Jag vet att min doktorandresa har varit stundtals tuff för familjen, inte minst under datainsamlingen och nu de senaste månaderna, men du har aldrig en enda dag ifrågasatt mitt val. Jag älskar och uppskattar ditt lugn och för att du för med dig det oväntade.

Sist och minst (i ålder), men bäst, **Gustav** and **Linn**, the bless, joy and love in my life, you are the best, always! Ni är båda två så kloka och fina. Dröm stort. Våga leva. Love you guys to the moon and back.

***Life is short, Break the Rules. Forgive quickly, Kiss slowly. Love truly. Laugh uncontrollably And never regret ANYTHING That makes you smile.***

***Mark Twain***

# 12 REFERENCES


1. Convertino VA, Bloomfield SA, Greenleaf JE. An overview of the issues: physiological effects of bed rest and restricted physical activity. Medicine and science in sports and exercise. 1997;29(2):187-90.

2. Allen C, Glasziou P, Del Mar C. Bed rest: a potentially harmful treatment needing more careful evaluation. Lancet (London, England). 1999;354(9186):1229-33.

3. Kehlet H, Dahl JB. Anaesthesia, surgery, and challenges in postoperative recovery. Lancet (London, England). 2003;362(9399):1921-8.

4. Dock W. The evil sequelae of complete bed rest. Journal of the American Medical Association. 1944;125(16):1083-5.

5. Lassen K, Soop M, Nygren J, Cox PB, Hendry PO, Spies C, et al. Consensus review of optimal perioperative care in colorectal surgery: Enhanced Recovery After Surgery (ERAS) Group recommendations. Archives of surgery (Chicago, Ill : 1960). 2009;144(10):961-9.

6. Global patient outcomes after elective surgery: prospective cohort study in 27 low-, middle- and high-income countries. British journal of anaesthesia. 2016;117(5):601-9.

7. Kalisch BJ, Lee S, Dabney BW. Outcomes of inpatient mobilization: a literature review. Journal of clinical nursing. 2014;23(11-12):1486-501.

8. Gustafsson UO, Scott MJ, Schwenk W, Demartines N, Roulin D, Francis N, et al. Guidelines for perioperative care in elective colonic surgery: Enhanced Recovery After Surgery (ERAS((R))) Society recommendations. World journal of surgery. 2013;37(2):259-84.

9. Cerantola Y, Valerio M, Persson B, Jichlinski P, Ljungqvist O, Hubner M, et al. Guidelines for perioperative care after radical cystectomy for bladder cancer: Enhanced Recovery After Surgery (ERAS(®)) society recommendations. Clinical nutrition (Edinburgh, Scotland). 2013;32(6):879-87.

10. Ljungqvist O, Scott M, Fearon KC. Enhanced Recovery After Surgery: A Review. JAMA surgery. 2017;152(3):292-8.

11. Collins JW, Patel H, Adding C, Annerstedt M, Dasgupta P, Khan SM, et al. Enhanced Recovery After Robot-assisted Radical Cystectomy: EAU Robotic Urology Section Scientific Working Group Consensus View. European urology. 2016;70(4):649-60.

12. Nelson G, Bakkum-Gamez J, Kalogera E, Glaser G, Altman A, Meyer LA, et al. Guidelines for perioperative care in gynecologic/oncology: Enhanced Recovery After Surgery (ERAS) Society recommendations-2019 update. International journal of gynecological cancer : official journal of the International Gynecological Cancer Society. 2019;29(4):651-68.

13. Statistikdatabas för operationer i slutenvård. Socialstyrelsen (Statistical database of operations in inpatient care) [Internet]. Socialstyrelsen. 2021 [cited 2021 April 10].

14. Brody F, Richards NG. Review of robotic versus conventional laparoscopic surgery. Surgical Endoscopy. 2014;28(5):1413-24.

15. Leal Ghezzi T, Campos Corleta O. 30 Years of Robotic Surgery. World journal of surgery. 2016;40(10):2550-7.

16. Roh HF, Nam SH, Kim JM. Robot-assisted laparoscopic surgery versus conventional laparoscopic surgery in randomized controlled trials: A systematic review and meta-analysis. PloS one. 2018;13(1):e0191628.

17. Manou-Stathopoulou V, Korbonits M, Ackland GL. Redefining the perioperative stress response: a narrative review. British journal of anaesthesia. 2019;123(5):570-83.

18. Gurusamy KS, Samraj K, Fusai G, Davidson BR. Robot assistant versus human or another robot assistant in patients undergoing laparoscopic cholecystectomy. The Cochrane database of systematic reviews. 2012(9):Cd006578.

19. Dureuil B, Cantineau JP, Desmonts JM. Effects of upper or lower abdominal surgery on diaphragmatic function. British journal of anaesthesia. 1987;59(10):1230-5.

20. Lumb AB. Chapter 2 - Elastic Forces and Lung Volumes. In: Lumb AB, editor. Nunn's Applied Respiratory Physiology (Eighth Edition): Elsevier; 2017. p. 17-32.e1.

21. Kalmar AF, Foubert L, Hendrickx JF, Mottrie A, Absalom A, Mortier EP, et al. Influence of steep Trendelenburg position and CO(2) pneumoperitoneum on cardiovascular, cerebrovascular, and respiratory homeostasis during robotic prostatectomy. British journal of anaesthesia. 2010;104(4):433-9.

22. Lumb AB. Nunn's applied respiratory physiology. Eighth edition ed. Edinburgh: Elsevier; 2016.

23. Lumb AB, Nunn JF. Respiratory function and ribcage contribution to ventilation in body positions commonly used during anesthesia. Anesthesia and analgesia. 1991;73(4):422-6.

24. Kilic OF, Borgers A, Kohne W, Musch M, Kropfl D, Groeben H. Effects of steep Trendelenburg position for robotic-assisted prostatectomies on intra- and extrathoracic airways in patients with or without chronic obstructive pulmonary disease. British journal of anaesthesia. 2015;114(1):70-6.

25. Gunnarsson L, Lindberg P, Tokics L, Thorstensson O, Thorne A. Lung function after open versus laparoscopic cholecystectomy. Acta anaesthesiologica Scandinavica. 1995;39(3):302-6.

26. Lawrence VA, Cornell JE, Smetana GW. Strategies to reduce postoperative pulmonary complications after noncardiothoracic surgery: systematic review for the American College of Physicians. Annals of internal medicine. 2006;144(8):596-608.

27. Wahba RW. Perioperative functional residual capacity. Canadian journal of anaesthesia = Journal canadien d'anesthesie. 1991;38(3):384-400.

28. Hedenstierna G, Strandberg A, Brismar B, Lundquist H, Tokics L. What causes the lowered FRC during anaesthesia? Clinical physiology (Oxford, England). 1985;5 Suppl 3:133-41.

29. Hedenstierna G, Edmark L. The effects of anesthesia and muscle paralysis on the respiratory system. Intensive care medicine. 2005;31(10):1327-35.

30. Blair E, Hickam JB. The effect of change in body position on lung volume and intrapulmonary gas mixing in normal subjects. The Journal of clinical investigation. 1955;34(3):383-9.

31. Tokics L, Strandberg A, Brismar B, Lundquist H, Hedenstierna G. Computerized tomography of the chest and gas exchange measurements during ketamine anaesthesia. Acta anaesthesiologica Scandinavica. 1987;31(8):684-92.

32. Hedenstierna G, Edmark L. Effects of anesthesia on the respiratory system. Best practice & research Clinical anaesthesiology. 2015;29(3):273-84.

33. Miskovic A, Lumb AB. Postoperative pulmonary complications. British journal of anaesthesia. 2017;118(3):317-34.

34. Duggan M, Kavanagh BP. Pulmonary atelectasis: a pathogenic perioperative entity. Anesthesiology. 2005;102(4):838-54.

35. Reber A, Nylund U, Hedenstierna G. Position and shape of the diaphragm: implications for atelectasis formation. Anaesthesia. 1998;53(11):1054-61.

36. Bendixen HH, Hedley-Whyte J, Laver MB. IMPAIRED OXYGENATION IN SURGICAL PATIENTS DURING GENERAL ANESTHESIA WITH CONTROLLED VENTILATION. A CONCEPT OF ATELECTASIS. The New England journal of medicine. 1963;269:991-6.

37. Kirmeier E, Eriksson LI, Lewald H, Jonsson Fagerlund M, Hoeft A, Hollmann M, et al. Post-anaesthesia pulmonary complications after use of muscle relaxants (POPULAR): a multicentre, prospective observational study. The Lancet Respiratory medicine. 2019;7(2):129-40.

38. Hedenstierna G, Edmark L, Perchiazzi G. Postoperative lung complications: have multicentre studies been of any help? British journal of anaesthesia. 2015;114(4):541-3.

39. Hedenstierna G, Edmark L. Mechanisms of atelectasis in the perioperative period. Best practice & research Clinical anaesthesiology. 2010;24(2):157-69.

40. Hedenstierna G, Rothen HU. Respiratory function during anesthesia: effects on gas exchange. Comprehensive Physiology. 2012;2(1):69-96.

41. Lindberg P, Gunnarsson L, Tokics L, Secher E, Lundquist H, Brismar B, et al. Atelectasis and lung function in the postoperative period. Acta anaesthesiologica Scandinavica. 1992;36(6):546-53.

42. Colucci DB, Fiore JF, Jr., Paisani DM, Risso TT, Colucci M, Chiavegato LD, et al. Cough impairment and risk of postoperative pulmonary complications after open upper abdominal surgery. Respiratory care. 2015;60(5):673-8.

43. Hedenstierna G. Oxygen and anesthesia: what lung do we deliver to the post-operative ward? Acta anaesthesiologica Scandinavica. 2012;56(6):675-85.

44. Smetana GW, Lawrence VA, Cornell JE. Preoperative pulmonary risk stratification for noncardiothoracic surgery: systematic review for the American College of Physicians. Annals of internal medicine. 2006;144(8):581-95.

45. Sabate S, Mazo V, Canet J. Predicting postoperative pulmonary complications: implications for outcomes and costs. Current opinion in anaesthesiology. 2014;27(2):201-9.

46. Fisher BW, Majumdar SR, McAlister FA. Predicting pulmonary complications after nonthoracic surgery: a systematic review of blinded studies. The American journal of medicine. 2002;112(3):219-25.

47. Canet J, Gallart L, Gomar C, Paluzie G, Valles J, Castillo J, et al. Prediction of postoperative pulmonary complications in a population-based surgical cohort. Anesthesiology. 2010;113(6):1338-50.

48. Fiore JF, Castelino T, Pecorelli N, Niculiseanu P, Alhashemi M, Hershorn O, et al. Randomized controlled trial of an intervention to facilitate early mobilization after colorectal surgery: Impact on postoperative pulmonary function and complications. European Respiratory Journal. 2017;50(suppl 61).

49. Neto AS, da Costa LGV, Hemmes SNT, Canet J, Hedenstierna G, Jaber S, et al. The LAS VEGAS risk score for prediction of postoperative pulmonary complications: An observational study. European journal of anaesthesiology. 2018;35(9):691-701.

50. Sachdev G, Napolitano LM. Postoperative pulmonary complications: pneumonia and acute respiratory failure. The Surgical clinics of North America. 2012;92(2):321-44, ix.

51. Jammer I, Wickboldt N, Sander M, Smith A, Schultz MJ, Pelosi P, et al. Standards for definitions and use of outcome measures for clinical effectiveness research in perioperative medicine: European Perioperative Clinical Outcome (EPCO) definitions: a statement from the ESA-ESICM joint taskforce on perioperative outcome measures. European journal of anaesthesiology. 2015;32(2):88-105.

52. Canet J, Gallart L. Postoperative respiratory failure: pathogenesis, prediction, and prevention. Current opinion in critical care. 2014;20(1):56-62.

53. Canet J, Sabate S, Mazo V, Gallart L, de Abreu MG, Belda J, et al. Development and validation of a score to predict postoperative respiratory failure in a multicentre European cohort: A prospective, observational study. European journal of anaesthesiology. 2015;32(7):458-70.

54. Parry S, Denehy L, Berney S, Browning L. Clinical application of the Melbourne risk prediction tool in a high-risk upper abdominal surgical population: an observational cohort study. Physiotherapy. 2014;100(1):47-53.

55. Fernandez-Bustamante A, Frendl G, Sprung J, Kor DJ, Subramaniam B, Martinez Ruiz R, et al. Postoperative Pulmonary Complications, Early Mortality, and Hospital Stay Following Noncardiothoracic Surgery: A Multicenter Study by the Perioperative Research Network Investigators. JAMA surgery. 2017;152(2):157-66.

56. Arozullah AM, Khuri SF, Henderson WG, Daley J. Development and validation of a multifactorial risk index for predicting postoperative pneumonia after major noncardiac surgery. Annals of internal medicine. 2001;135(10):847-57.

57. Gallart L, Canet J. Post-operative pulmonary complications: Understanding definitions and risk assessment. Best practice & research Clinical anaesthesiology. 2015;29(3):315-30.

58. Futier E, Constantin JM, Petit A, Jung B, Kwiatkowski F, Duclos M, et al. Positive end-expiratory pressure improves end-expiratory lung volume but not oxygenation after induction of anaesthesia. European journal of anaesthesiology. 2010;27(6):508-13.

59. Ries E. Some radical changes in the after-treatment of celiotomy cases. JAMA. 1899;33:454-6.

60. Brieger GH. Early ambulation. A study in the history of surgery. Annals of surgery. 1983;197(4):443-9.

61. Hashem MD, Nelliot A, Needham DM. Early Mobilization and Rehabilitation in the ICU: Moving Back to the Future. Respiratory care. 2016;61(7):971-9.

62. Canavarro K. Early postoperative ambulation. Annals of surgery. 1946;124:180.

63. Engelman RM, Rousou JA, Flack JE, 3rd, Deaton DW, Humphrey CB, Ellison LH, et al. Fast-track recovery of the coronary bypass patient. The Annals of thoracic surgery. 1994;58(6):1742-6.

64. Bardram L, Funch-Jensen P, Jensen P, Crawford ME, Kehlet H. Recovery after laparoscopic colonic surgery with epidural analgesia, and early oral nutrition and mobilisation. Lancet (London, England). 1995;345(8952):763-4.

65. Kehlet H, Mogensen T. Hospital stay of 2 days after open sigmoidectomy with a multimodal rehabilitation programme. The British journal of surgery. 1999;86(2):227-30.

66. Basse L, Hjort Jakobsen D, Billesbølle P, Werner M, Kehlet H. A clinical pathway to accelerate recovery after colonic resection. Annals of surgery. 2000;232(1):51-7.

67. Lassen K, Coolsen MM, Slim K, Carli F, de Aguilar-Nascimento JE, Schäfer M, et al. Guidelines for perioperative care for pancreaticoduodenectomy: Enhanced Recovery After Surgery (ERAS®) Society recommendations. World journal of surgery. 2013;37(2):240-58.

68. Nelson G, Altman AD, Nick A, Meyer LA, Ramirez PT, Achtari C, et al. Guidelines for postoperative care in gynecologic/oncology surgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations--Part II. Gynecologic oncology. 2016;140(2):323-32.

69. Nicholson A, Lowe MC, Parker J, Lewis SR, Alderson P, Smith AF. Systematic review and meta-analysis of enhanced recovery programmes in surgical patients. The British journal of surgery. 2014;101(3):172-88.

70. Cameron S, Ball I, Cepinskas G, Choong K, Doherty TJ, Ellis CG, et al. Early mobilization in the critical care unit: A review of adult and pediatric literature. Journal of critical care. 2015;30(4):664-72.

71. Pashikanti L, Von Ah D. Impact of early mobilization protocol on the medical-surgical inpatient population: an integrated review of literature. Clinical nurse specialist CNS. 2012;26(2):87-94.

72. Clarissa C, Salisbury L, Rodgers S, Kean S. Early mobilisation in mechanically ventilated patients: a systematic integrative review of definitions and activities. Journal of intensive care. 2019;7:3.

73. Castro E, Turcinovic M, Platz J, Law I. Early Mobilization: Changing the Mindset. Critical Care Nurse. 2015;35(4):e1-e6.

74. Ding N, Zhang Z, Zhang C, Yao L, Yang L, Jiang B, et al. What is the optimum time for initiation of early mobilization in mechanically ventilated patients? A network meta-analysis. PloS one. 2019;14(10):e0223151.

75. Melloul E, Lassen K, Roulin D, Grass F, Perinel J, Adham M, et al. Guidelines for Perioperative Care for Pancreatoduodenectomy: Enhanced Recovery After Surgery (ERAS) Recommendations 2019. World journal of surgery. 2020;44(7):2056-84.

76. Gustafsson UO, Hausel J, Thorell A, Ljungqvist O, Soop M, Nygren J. Adherence to the enhanced recovery after surgery protocol and outcomes after colorectal cancer surgery. Archives of surgery (Chicago, Ill : 1960). 2011;146(5):571-7.

77. Huang ZD, Gu HY, Zhu J, Luo J, Shen XF, Deng QF, et al. The application of enhanced recovery after surgery for upper gastrointestinal surgery: Meta-analysis. BMC surgery. 2020;20(1):3.

78. Grass F, Pache B, Martin D, Addor V, Hahnloser D, Demartines N, et al. Feasibility of early postoperative mobilisation after colorectal surgery: A retrospective cohort study. International journal of surgery (London, England). 2018;56:161-6.

79. Kigin CM. Chest physical therapy for the postoperative or traumatic injury patient. Physical therapy. 1981;61(12):1724-36.

80. Hough A. Physiotherapy in respiratory care: a problem-solving approach to respiratory and cardiac management: Springer; 2013.

81. Hanekom SD, Brooks D, Denehy L, Fagevik-Olsen M, Hardcastle TC, Manie S, et al. Reaching consensus on the physiotherapeutic management of patients following upper abdominal surgery: a pragmatic approach to interpret equivocal evidence. BMC medical informatics and decision making. 2012;12:5.

82. Bartlett D, Jr. Origin and regulation of spontaneous deep breaths. Respiration physiology. 1971;12(2):230-8.

83. Westerdahl E, Olsen MF. Chest physiotherapy and breathing exercises for cardiac surgery patients in Sweden--a national survey of practice. Monaldi archives for chest disease = Archivio Monaldi per le malattie del torace. 2011;75(2):112-9.

84. Fagevik Olsen M, Lannefors L, Westerdahl E. Positive expiratory pressure - Common clinical applications and physiological effects. Respiratory medicine. 2015;109(3):297-307.

85. Johansson H, Sjöholm R, Stafberg A, Westerdahl E. Breathing exercises with positive expiratory pressure after abdominal surgery - The current physical therapy practice in Sweden. J Anesthe Clinic Res. 2013;4.

86. Fagevik Olsén M, Larsson M. Breathing exercises with PEP-what happens to the breathing pattern during a session. Nordisk Fysioterapi. 2005;9:195-200.

87. Urell C, Emtner M, Hedenstrom H, Tenling A, Breidenskog M, Westerdahl E. Deep breathing exercises with positive expiratory pressure at a higher rate improve oxygenation in the early period after cardiac surgery--a randomised controlled trial. European journal of cardio-thoracic surgery : official journal of the European Association for Cardio-thoracic Surgery. 2011;40(1):162-7.

88. Orman J, Westerdahl E. Chest physiotherapy with positive expiratory pressure breathing after abdominal and thoracic surgery: a systematic review. Acta anaesthesiologica Scandinavica. 2010;54(3):261-7.

89. Colgan FJ, Mahoney PD, Fanning GL. Resistance breathing (blow bottles) and sustained hyperinflations in the treatment of atelectasis. Anesthesiology. 1970;32(6):543-50.

90. Ricksten SE, Bengtsson A, Soderberg C, Thorden M, Kvist H. Effects of periodic positive airway pressure by mask on postoperative pulmonary function. Chest. 1986;89(6):774-81.

91. Christensen EF, Schultz P, Jensen OV, Egebo K, Engberg M, Gron I, et al. Postoperative pulmonary complications and lung function in high-risk patients: a comparison of three physiotherapy regimens after upper abdominal surgery in general anesthesia. Acta anaesthesiologica Scandinavica. 1991;35(2):97-104.

92. Fagevik Olsen M, Hahn I, Nordgren S, Lonroth H, Lundholm K. Randomized controlled trial of prophylactic chest physiotherapy in major abdominal surgery. The British journal of surgery. 1997;84(11):1535-8.

93. Westerdahl E, Lindmark B, Eriksson T, Friberg O, Hedenstierna G, Tenling A. Deep-breathing exercises reduce atelectasis and improve pulmonary function after coronary artery bypass surgery. Chest. 2005;128(5):3482-8.

94. Stock MC, Downs JB, Gauer PK, Alster JM, Imrey PB. Prevention of postoperative pulmonary complications with CPAP, incentive spirometry, and conservative therapy. Chest. 1985;87(2):151-7.

95. Ibanez J, Raurich JM. Normal values of functional residual capacity in the sitting and supine positions. Intensive care medicine. 1982;8(4):173-7.

96. Nielsen KG, Holte K, Kehlet H. Effects of posture on postoperative pulmonary function. Acta anaesthesiologica Scandinavica. 2003;47(10):1270-5.

97. Moreno F, Lyons HA. Effect of body posture on lung volumes. Journal of applied physiology. 1961;16:27-9.

98. Hsu HO, Hickey RF. Effect of posture on functional residual capacity postoperatively. Anesthesiology. 1976;44(6):520-1.

99. Craig DB, Wahba WM, Don HF, Couture JG, Becklake MR. "Closing volume" and its relationship to gas exchange in seated and supine positions. Journal of applied physiology. 1971;31(5):717-21.

100. Meyers JR, Lembeck L, O'Kane H, Baue AE. Changes in functional residual capacity of the lung after operation. Archives of surgery (Chicago, Ill : 1960). 1975;110(5):576-83.

101. Scheidegger D, Bentz L, Piolino G, Pusterla C, Gigon JP. Influence of early mobilisation of pulmonary function in surgical patients. European journal of intensive care medicine. 1976;2(1):35-40.

102. Mynster T, Jensen LM, Jensen FG, Kehlet H, Rosenberg J. The effect of posture on late postoperative oxygenation. Anaesthesia. 1996;51(3):225-7.

103. Kaneda H, Saito Y, Okamoto M, Maniwa T, Minami K, Imamura H. Early postoperative mobilization with walking at 4 hours after lobectomy in lung cancer patients. General thoracic and cardiovascular surgery. 2007;55(12):493-8.

104. Fagevik Olsén M, Becovic S, Dean E. Short-term effects of mobilization on oxygenation in patients after open surgery for pancreatic cancer: a randomized controlled trial. BMC surgery. 2021;21(1):185.

105. Castelino T, Fiore JF, Jr., Niculiseanu P, Landry T, Augustin B, Feldman LS. The effect of early mobilization protocols on postoperative outcomes following abdominal and thoracic surgery: A systematic review. Surgery. 2016;159(4):991-1003.

106. Hanada M, Kanetaka K, Hidaka S, Taniguchi K, Oikawa M, Sato S, et al. Effect of early mobilization on postoperative pulmonary complications in patients undergoing video-assisted thoracoscopic surgery on the esophagus. Esophagus : official journal of the Japan Esophageal Society. 2018;15(2):69-74.

107. Hu Y, McArthur A, Yu Z. Early postoperative mobilization in patients undergoing abdominal surgery: a best practice implementation project. JBI database of systematic reviews and implementation reports. 2019;17(12):2591-611.

108. Kokotovic D, Berkfors A, Gögenur I, Ekeloef S, Burcharth J. The effect of postoperative respiratory and mobilization interventions on postoperative complications following abdominal surgery: a systematic review and meta-analysis. European journal of trauma and emergency surgery : official publication of the European Trauma Society. 2020.

109. Ni CY, Wang ZH, Huang ZP, Zhou H, Fu LJ, Cai H, et al. Early enforced mobilization after liver resection: A prospective randomized controlled trial. International journal of surgery (London, England). 2018;54(Pt A):254-8.

110. Schaller SJ, Anstey M, Blobner M, Edrich T, Grabitz SD, Gradwohl-Matis I, et al. Early, goal-directed mobilisation in the surgical intensive care unit: a randomised controlled trial. Lancet (London, England). 2016;388(10052):1377-88.

111. Forgiarini LA, Jr., Carvalho AT, Ferreira Tde S, Monteiro MB, Dal Bosco A, Goncalves MP, et al. Physical therapy in the immediate postoperative period after abdominal surgery. Jornal brasileiro de pneumologia : publicacao oficial da Sociedade Brasileira de Pneumologia e Tisilogia. 2009;35(5):455-9.

112. Mackay MR, Ellis E, Johnston C. Randomised clinical trial of physiotherapy after open abdominal surgery in high risk patients. The Australian journal of physiotherapy. 2005;51(3):151-9.

113. Silva YR, Li SK, Rickard MJ. Does the addition of deep breathing exercises to physiotherapy-directed early mobilisation alter patient outcomes following high-risk open upper abdominal surgery? Cluster randomised controlled trial. Physiotherapy. 2013;99(3):187-93.

114. Ohlsson-Nevo E, Andersson G, Nilsing Strid E. In the hands of nurses: A focus group study of how nurses perceive and promote inpatients' needs for physical activity. 2020;7(1):334-44.

115. Sepulveda-Pacsi AL, Soderman M, Kertesz L. Nurses' perceptions of their knowledge and barriers to ambulating hospitalized patients in acute settings. Applied nursing research : ANR. 2016;32:117-21.

116. Pearsall EA, Meghji Z, Pitzul KB, Aarts MA, McKenzie M, McLeod RS, et al. A qualitative study to understand the barriers and enablers in implementing an enhanced recovery after surgery program. Annals of surgery. 2015;261(1):92-6.

117. Brown CJ, Williams BR, Woodby LL, Davis LL, Allman RM. Barriers to mobility during hospitalization from the perspectives of older patients and their nurses and physicians. 2007;2(5):305-13.

118. Barber EA, Everard T, Holland AE, Tipping C, Bradley SJ, Hodgson CL. Barriers and facilitators to early mobilisation in Intensive Care: a qualitative study. Australian critical care : official journal of the Confederation of Australian Critical Care Nurses. 2015;28(4):177-82; quiz 83.

119. Fontela PC, Forgiarini LA, Jr., Friedman G. Clinical attitudes and perceived barriers to early mobilization of critically ill patients in adult intensive care units. Revista Brasileira de terapia intensiva. 2018;30(2):187-94.

120. Jolley SE, Regan-Baggs J, Dickson RP, Hough CL. Medical intensive care unit clinician attitudes and perceived barriers towards early mobilization of critically ill patients: a cross-sectional survey study. BMC anesthesiology. 2014;14:84.

121. Kim C, Kim S, Yang J, Choi M. Nurses' perceived barriers and educational needs for early mobilisation of critical ill patients. Australian Critical Care. 2019;32(6):451-7.

122. Koo KK, Choong K, Cook DJ, Herridge M, Newman A, Lo V, et al. Early mobilization of critically ill adults: a survey of knowledge, perceptions and practices of Canadian physicians and physiotherapists. CMAJ open. 2016;4(3):E448-e54.

123. Leditschke IA, Green M, Irvine J, Bissett B, Mitchell IA. What are the barriers to mobilizing intensive care patients? Cardiopulmonary physical therapy journal. 2012;23(1):26-9.

124. Morris PE. Moving our critically ill patients: mobility barriers and benefits. Critical care clinics. 2007;23(1):1-20.

125. Winkelman C, Peereboom K. Staff-perceived barriers and facilitators. Critical Care Nurse. 2010;30(2):S13-S6.

126. Parry SM, Knight LD, Connolly B, Baldwin C, Puthucheary Z, Morris P, et al. Factors influencing physical activity and rehabilitation in survivors of critical illness: a systematic review of quantitative and qualitative studies. Intensive care medicine. 2017;43(4):531-42.

127. Dubb R, Nydahl P, Hermes C, Schwabbauer N, Toonstra A, Parker AM, et al. Barriers and Strategies for Early Mobilization of Patients in Intensive Care Units. Annals of the American Thoracic Society. 2016;13(5):724-30.

128. Jonsson CA, Stenberg A, Frisman GH. The lived experience of the early postoperative period after colorectal cancer surgery. European Journal of Cancer Care. 2011;20(2):248-56.

129. Blazeby JM, Soulsby M, Winstone K, King PM, Bulley S, Kennedy RH. A qualitative evaluation of patients' experiences of an enhanced recovery programme for colorectal cancer. Colorectal disease : the official journal of the Association of Coloproctology of Great Britain and Ireland. 2010;12(10 Online):e236-42.

130. Taylor C, Burch J. Feedback on an enhanced recovery programme for colorectal surgery. British journal of nursing (Mark Allen Publishing). 2011;20(5):286-90.

131. Norlyk A, Harder I. After colonic surgery: The lived experience of participating in a fast-track programme. International journal of qualitative studies on health and well-being. 2009;4:170-80.

132. Soderberg A, Karlsson V, Ahlberg BM, Johansson A, Thelandersson A. From fear to fight: Patients experiences of early mobilization in intensive care. A qualitative interview study. Physiotherapy theory and practice. 2020:1-9.

133. Zheng K, Sarti A, Boles S, Cameron S, Carlisi R, Clark H, et al. Impressions of Early Mobilization of Critically Ill Children-Clinician, Patient, and Family Perspectives. Pediatric critical care medicine : a journal of the Society of Critical Care Medicine and the World Federation of Pediatric Intensive and Critical Care Societies. 2018;19(7):e350-e7.

134. Corner EJ, Murray EJ, Brett SJ. Qualitative, grounded theory exploration of patients' experience of early mobilisation, rehabilitation and recovery after critical illness. BMJ open. 2019;9(2):e026348.

135. Hughes M, Coolsen MM, Aahlin EK, Harrison EM, McNally SJ, Dejong CH, et al. Attitudes of patients and care providers to enhanced recovery after surgery programs after major abdominal surgery. The Journal of surgical research. 2015;193(1):102-10.

136. Sibbern T, Bull Sellevold V, Steindal SA, Dale C, Watt-Watson J, Dihle A. Patients' experiences of enhanced recovery after surgery: a systematic review of qualitative studies. Journal of clinical nursing. 2017;26(9-10):1172-88.

137. Alawadi ZM, Leal I, Phatak UR, Flores-Gonzalez JR, Holihan JL, Karanjawala BE, et al. Facilitators and barriers of implementing enhanced recovery in colorectal surgery at a safety net hospital: A provider and patient perspective. Surgery. 2016;159(3):700-12.

138. Hickmann CE, Castanares-Zapatero D, Bialais E, Dugernier J, Tordeur A, Colmant L, et al. Teamwork enables high level of early mobilization in critically ill patients. Annals of intensive care. 2016;6(1):80.

139. Cott C, Finch E, Gasner D, Yoshida K, Thomas S, Verrier MJPC. The movement continuum theory of physical therapy. Physiotherapy Canada. 1995;47(2):87-96.

140. Hijazi Y, Gondal U, Aziz O. A systematic review of prehabilitation programs in abdominal cancer surgery. International journal of surgery (London, England). 2017;39:156-62.

141. Scheede-Bergdahl C, Minnella EM, Carli F. Multi-modal prehabilitation: addressing the why, when, what, how, who and where next? Anaesthesia. 2019;74 Suppl 1:20-6.

142. Patton MQ. Qualitative Research and Evaluation methods: Intergrating Theory and Practice. . 4th ed. Thousand Oaks, CA, USA: SAGE Publications; 2015.

143. Fitz-Henry J. The ASA classification and peri-operative risk. Annals of the Royal College of Surgeons of England. 2011;93(3):185-7.

144. Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, et al. Standardisation of spirometry. The European respiratory journal. 2005;26(2):319-38.

145. Price B. Laddered questions and qualitative data research interviews. Journal of advanced nursing. 2002;37(3):273-81.

146. McMorrow RC, Mythen MG. Pulse oximetry. Current opinion in critical care. 2006;12(3):269-71.

147. Jubran A. Pulse oximetry. Critical care (London, England). 2015;19(1):272.

148. Williams AJ. ABC of oxygen: assessing and interpreting arterial blood gases and acid-base balance. BMJ (Clinical research ed). 1998;317(7167):1213-6.

149. Graham BL, Steenbruggen I, Miller MR, Barjaktarevic IZ, Cooper BG, Hall GL, et al. Standardization of Spirometry 2019 Update. An Official American Thoracic Society and European Respiratory Society Technical Statement. American journal of respiratory and critical care medicine. 2019;200(8):e70-e88.

150. Williamson A, Hoggart B. Pain: a review of three commonly used pain rating scales. Journal of clinical nursing. 2005;14(7):798-804.

151. Armstrong RA. Recommendations for analysis of repeated-measures designs: testing and correcting for sphericity and use of manova and mixed model analysis. Ophthalmic & physiological optics : the journal of the British College of Ophthalmic Opticians (Optometrists). 2017;37(5):585-93.

152. Brown H. Applied mixed models in medicine. 3rd ed. ed. Prescott R, editor. Chichester, England: Wiley; 2015.

153. White IR, Carpenter J, Horton NJ. Including all individuals is not enough: lessons for intention-to-treat analysis. Clinical trials (London, England). 2012;9(4):396-407.

154. Bell ML, Fiero M, Horton NJ, Hsu CH. Handling missing data in RCTs; a review of the top medical journals. BMC medical research methodology. 2014;14:118.

155. Schulz KF, Grimes DA. Sample size slippages in randomised trials: exclusions and the lost and wayward. Lancet (London, England). 2002;359(9308):781-5.

156. Armstrong RA. When to use the Bonferroni correction. Ophthalmic & physiological optics : the journal of the British College of Ophthalmic Opticians (Optometrists). 2014;34(5):502-8.

157. Wakkee M, Hollestein LM, Nijsten T. Multivariable analysis. The Journal of investigative dermatology. 2014;134(5):1-5.

158. Krippendorff K. Content analysis: An introduction to its methodology. 4th ed. Los Angeles, CA, USA: SAGE Publications; 2019.

159. Graneheim UH, Lundman B. Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. Nurse education today. 2004;24(2):105-12.

160. Elo S, Kyngas H. The qualitative content analysis process. Journal of advanced nursing. 2008;62(1):107-15.

161. Tracy SJ. Qualitative quality: Eight “big-tent” criteria for excellent qualitative research. Qualitative inquiry. 2010;16(10):837-51.

162. Graneheim UH, Lindgren BM, Lundman B. Methodological challenges in qualitative content analysis: A discussion paper. Nurse education today. 2017;56:29-34.

163. Hermerén G. God forskningssed: Vetenskapsrådet; 2011.

164. Association WM. World Medical Association Declaration of Helsinki. Ethical principles for medical research involving human subjects. Bulletin of the World Health Organization. 2001;79(4):373.

165. World Medical A. World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects. JAMA : the journal of the American Medical Association. 2013;310(20):2191-4.

166. Orb A, Eisenhauer L, Wynaden D. Ethics in Qualitative Research. 2001;33(1):93-6.

167. Gillon R. Medical ethics: four principles plus attention to scope. BMJ (Clinical research ed). 1994;309(6948):184-8.

168. Jenkins SC, Soutar SA, Moxham J. The effects of posture on lung volumes in normal subjects and in patients pre-and post-coronary artery surgery. Physiotherapy. 1988;74(10):492-6.

169. Craig DB. Postoperative recovery of pulmonary function. Anesthesia and analgesia. 1981;60(1):46-52.

170. Lachmann B. Open up the lung and keep the lung open. Intensive care medicine. 1992;18(6):319-21.

171. Katz S, Arish N, Rokach A, Zaltzman Y, Marcus EL. The effect of body position on pulmonary function: a systematic review. BMC pulmonary medicine. 2018;18(1):159.

172. Schooling CM, Jones HE. Clarifying questions about "risk factors": predictors versus explanation. Emerging themes in epidemiology. 2018;15:10.

173. Topp R, Ditmyer M, King K, Doherty K, Hornyak J, 3rd. The effect of bed rest and potential of prehabilitation on patients in the intensive care unit. AACN clinical issues. 2002;13(2):263-76.

174. Aasa A, Hovback M, Bertero CM. The importance of preoperative information for patient participation in colorectal surgery care. Journal of clinical nursing. 2013;22(11-12):1604-12.

175. Vollman KM. Understanding critically ill patients hemodynamic response to mobilization: using the evidence to make it safe and feasible. Critical care nursing quarterly. 2013;36(1):17-27.

176. Gustafsson S, Strömqvist M, Ekelund J, Engström Å. Factors Influencing Early Postoperative Recovery After Laparoscopic Cholecystectomy. Journal of perianesthesia nursing : official journal of the American Society of PeriAnesthesia Nurses. 2020;35(1):80-4.

177. Fletcher N, Engelman DT. Postoperative care: who should look after patients following surgery? 2020;75(S1):e5-e9.

178. Hall P, Weaver L. Interdisciplinary education and teamwork: a long and winding road. Medical education. 2001;35(9):867-75.

179. Hermes C, Nydahl P, Blobner M, Dubb R, Filipovic S, Kaltwasser A, et al. Assessment of mobilization capacity in 10 different ICU scenarios by different professions. PloS one. 2020;15(10):e0239853.

180. Leonard M, Graham S, Bonacum D. The human factor: the critical importance of effective teamwork and communication in providing safe care. Quality & safety in health care. 2004;13 Suppl 1(Suppl 1):i85-90.

181. Framework for action on interprofessional education & collaborative practice. http://www.who.int/hrh/resources/framework_action/en/: World Health Organization; 2010 [cited 2020 Dec 28].

182. WCPT. WCPT Policy Statement: Description of Physical Therapy. World Confederation of Physical Therapy [web page]. https://world.physio/policy/ps-descriptionPT: WCPT; 2021 [

183. Garzon-Serrano J, Ryan C, Waak K, Hirschberg R, Tully S, Bittner EA, et al. Early mobilization in critically ill patients: patients' mobilization level depends on health care provider's profession. PM & R : the journal of injury, function, and rehabilitation. 2011;3(4):307-13.

184. Amundadottir OR, Jonsdottir H, Sigurdsson GH, Dean E. Physical Therapists' Clinical Reasoning and Decision-Making Processes When Mobilizing Patients Who Are Critically Ill: A Qualitative Study. Cardiopulmonary physical therapy journal. 2018;29 (1):13-25.

185. Nichol AD, Bailey M, Cooper DJ. Challenging issues in randomised controlled trials. Injury. 2010;41 Suppl 1:S20-3.

186. Akl EA, Briel M, You JJ, Sun X, Johnston BC, Busse JW, et al. Potential impact on estimated treatment effects of information lost to follow-up in randomised controlled trials (LOST-IT): systematic review. BMJ (Clinical research ed). 2012;344:e2809.

187. Gupta SK. Intention-to-treat concept: A review. Perspect Clin Res. 2011;2(3):109-12.

188. Vetter TR, Mascha EJ. Bias, Confounding, and Interaction: Lions and Tigers, and Bears, Oh My! Anesthesia and analgesia. 2017;125(3):1042-8.

189. Kimberlin CL, Winterstein AG. Validity and reliability of measurement instruments used in research. American journal of health-system pharmacy : AJHP : official journal of the American Society of Health-System Pharmacists. 2008;65(23):2276-84.

190. Petterson MT, Begnoche VL, Graybeal JM. The effect of motion on pulse oximetry and its clinical significance. Anesthesia and analgesia. 2007;105(6 Suppl):S78-84.

191. Burcharth J, Ohm Oreskov J, Falkenberg A, Schack A, Ekeloef S, Gögenur I. Respiratory function following major emergency abdominal surgery. Journal of perioperative practice. 2020;30(12):389-94.

192. Fuso L, Cisternino L, Di Napoli A, Di Cosmo V, Tramaglino LM, Basso S, et al. Role of spirometric and arterial gas data in predicting pulmonary complications after abdominal surgery. Respiratory medicine. 2000;94(12):1171-6.

193. Creswell JW, Miller DL. Determining validity in qualitative inquiry. Theory into practice. 2000;39(3):124-30.

194. Malterud K. Qualitative research: standards, challenges, and guidelines. Lancet (London, England). 2001;358(9280):483-8.

195. Polit DF, Beck CT. Generalization in quantitative and qualitative research: myths and strategies. International journal of nursing studies. 2010;47(11):1451-8.