ELSEVIER

Physiotherapy 127 (2025) 101462

Physiotherapy

Current practice of targeted breathing exercises after abdominal and cardiothoracic surgery: a national multicentre observational study

Monika Fagevik Olsén[a,b,*], Anna Svensson-Raskh[c,d], Elisabeth Westerdahl[e], Malin Nygren Bonnier[c,d], Julie Reeve[f], Maria Sehlin[g]

[a] Department of Health and Rehabilitation/Physiotherapy, Institute of Neuroscience and Physiology, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden
[b] Department of Surgery, Institute of Clinical Sciences, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden
[c] Department of Neurobiology, Care Sciences and Society, Division of Physiotherapy, Karolinska Institutet, Stockholm, Sweden
[d] Women´s Health and Allied Health Professionals Theme, Medical Unit Allied Health Professionals, Karolinska University Hospital, Stockholm, Sweden
[e] University Health Care Research Center, Faculty of Medicine and Health, Örebro University, Örebro, Sweden
[f] School of Clinical Sciences, Faculty of Health, and Environmental Studies, AUT University, Auckland, New Zealand
[g] Department of Community Medicine and Rehabilitation/Physiotherapy, Umeå University, Umeå, Sweden

Abstract

Objectives To describe the timing and type of the first targeted breathing exercises after abdominal and cardiothoracic surgery, and to identify factors associated with early initiation (Commencement within three hours after arriival to a postoperative ward).

Design Multicentre observational study.

Methods In 18 hospitals in Sweden, the start time and type of targeted breathing exercises were recorded in consecutive series of patients who underwent abdominal or cardiothoracic surgery. Demographic data were retrieved from hospital records. Patients were divided into seven groups based on the category of surgery.

Results In total, 1492 patients were included in this study; of these, 1128 (76%) performed some form of targeted breathing exercise after surgery. Targeted breathing exercises commenced a median of 3.63 hours (interquartile range 1.58 to 11.75 hours) after arrival on a postoperative ward, with earlier commencement after minor abdominal surgery and later commencement after major abdominal surgery ($P < 0.001$). Most patients who performed targeted breathing exercises used positive expiratory pressure (n = 968/1492, 65%) or deep breathing without any devices (n = 207/1492, 14%). The odds of initiating breathing exercises within the first 3 hours after arrival on a postoperative ward were higher if a patient underwent pulmonary or abdominal surgery [odds ratio (OR) > 2.04; $P < 0.001$], or had intravenous analgesia (OR 1.50, 95% CI 1.05 to 2.14; $P = 0.026$). The odds were lower (OR 0.43, 95% CI 0.21 to 0.88; $P = 0.021$) for patients who arrived on the postoperative ward in the evening/night or for patients who had undergone laparoscopic surgery (OR 0.63, 0.43-0.92, p=0.018).

Conclusion The majority (76%) of patients undergoing abdominal or cardiothoracic surgery performed some form of targeted breathing exercise, starting a median of 3.63 hours after arrival on a postoperative ward.

Trial registration "FoU in Sweden" (Research and Development in Sweden) ID: 275357 and Clinical Trials NCT04729634.

* Correspondence: Sahlgrenska Academy/Department of Neuroscience and Physiology/Physiotherapy, University of Gothenburg, Box 100, SE 405 30 Gothenburg, Sweden.
E-mail address: monika.fagevik-olsen@gu.se (M. Fagevik Olsén).

https://doi.org/10.1016/j.physio.2024.101462

Contribution of the Paper

- To the authors' knowledge, this is the first study to survey national clinical practice regarding the use of targeted breathing exercises during the first 24 hours after abdominal or cardiothoracic surgery.
- Baseline data from this study can be used as comparative material for other countries.

Keywords: Abdominal surgery; Breathing exercises; Cardiothoracic surgery; Postoperative

Introduction

Patients undergoing major cardiothoracic and abdominal surgery are at increased risk of developing postoperative pulmonary complications (PPCs) [1,2]. For decades, physiotherapists have used different interventions to prevent PPCs. These interventions may include prehabilitation; pre-operative education; early postoperative mobilisation; and different types of breathing exercises such as deep breathing exercises (DBEs), incentive spirometry (IS), active cycle of breathing techniques (ACBTs), positive expiratory pressure (PEP) and inspiratory muscle training (IMT) [3,4]. Despite the widespread use of such exercises, there is limited consensus about their impact. Moreover, there is no consensus about when and how to apply them, and which patients gain the greatest benefit from their use [3–9]. There are several reasons for this lack of consensus, including the heterogeneity of investigating trials, their overall quality, and the validity of some of the outcome measures used to determine efficacy. Expert consensus guidelines based on the best-quality evidence have been published to guide physiotherapists in providing the best physiotherapeutic practice after major surgery [10]. These guidelines recommend that patients should be taught to use breathing exercises such as DBEs, PEP and continuous positive airway pressure (CPAP) in combination with airway clearance techniques. Although there is no consensus on when treatment should commence, starting as early as possible after surgery would likely be beneficial in order to increase lung volume and subsequently reduce the risk of PPCs, especially for those at high risk.

Surveys of interventions for patients undergoing abdominal and cardiothoracic surgery have been undertaken to describe national physiotherapeutic practices [11–24]. The results show diversity in clinical practice across and within countries, but most include a clinical preference for incorporating different targeted DBEs, such as PEP, and different airway clearance techniques in their treatment regimens. Nonetheless, data in these studies are based on responses to written surveys about clinical practice, giving subjective responses or opinions of physiotherapists and other healthcare professionals. Therefore, observational data regarding the use of breathing exercises postoperatively are lacking. Such studies could assist in describing how targeted breathing exercises are applied, and help to improve postoperative care after abdominal and cardiothoracic surgery.

This national study aimed to investigate and describe the timing of initiation and type of the first targeted breathing exercises started after abdominal and cardiothoracic surgery, and to identify factors associated with early initiation (within 3 hours after arrival on a postoperative ward).

Methods

This study is part of the SOMBATA (Survey Of Mobilisation and Breathing exercises After Thoracic and Abdominal surgery) study, a prospective observational national multicentre cohort study that investigated the practice of mobilisation and breathing exercises during the first 24 hours after surgery in Sweden. This part of the SOMBATA study investigated the initiation of targeted breathing exercises within 24 hours of abdominal or cardiothoracic surgery.

The STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) checklist was used to report this data. The Swedish Ethical Review Authority approved the study (Registration No. 2020-03108), as well as all heads of departments involved (surgery, anaesthesiology and physiotherapy). Patient consent was waived due to the observational study design and the fact that no changes to usual care were implemented.

Context of the study

In Sweden, patients scheduled to undergo abdominal or cardiothoracic surgery are often given information by a physiotherapist pre-operatively. This includes information about early mobilisation and DBEs, and patients undergoing major abdominal or cardiothoracic procedures are often prescribed targeted breathing exercises with devices. Some categories of patients are included in prehabilitation programmes, which may include breathing exercises, such as IMT. After receiving the instructions, the patients are supposed to be responsible for the prescribed training.

After surgery, patients are transferred to postoperative care which may take place in intensive care units (ICUs), specific postoperative units, or intermediate units (in between an ICU/postoperative unit and a surgical ward). In accordance with Swedish guidelines, breathing exercises should be started soon after arrival on the postoperative ward, regardless of the level of care [25]. The targeted breathing exercises may be initiated by the patients themselves by following the instructions received pre-operatively, or can be initiated by physiotherapists or nurses. In addition, multimodal perioperative care pathways, including early mobilisation and breathing exercises, are used for some categories of patients.

Data collection

Adults (age ≥18 years) undergoing acute (planned < 24 hours before), subacute (planned > 24 hours before surgery on patients who are in hospital) or elective open, laparoscopic or robot-assisted surgery within the abdomen or thorax with a planned duration of anaesthesia > 2 hours were included in this study. The exclusion criteria were plastic, trauma, transplant or orthopaedic surgery. Operations were categorised into seven categories:

- Cardiac: coronary artery bypass graft, valve surgery and aortic surgery via sternotomy.
- Thoracic: pulmonary surgery via thoracotomy or thoracoscopy.
- Major upper abdominal: pancreatic, hepatic, oesophageal and ventricular open procedures.
- Minor upper abdominal: minor and laparoscopic procedures, such as fundoplication.
- Intestinal: small intestine and colorectal surgery.
- Major lower abdominal: more extensive gynaecological, urological and other procedures close to the pubic bone.
- Minor lower abdominal: smaller or shorter gynaecological, urological and other procedures close to the pubic bone.

In order to recruit patients, an invitation to participate was sent to all physiotherapists in the Swedish cardiorespiratory special interest group and the network of physiotherapists in intensive care. In addition, representatives of physiotherapists from different hospitals were contacted. Eighteen hospitals consented to participate, which included all university hospitals (n = 7), and 11 of 70 (16%) regional or local county hospitals. These hospitals represented all regions of Sweden (see online supplementary material). Participants were invited to take part in the study at a self-selected convenient time, which could be any time between September 2021 and February 2022. During this period, data were collected for 5 consecutive weeks. To capture practice on weekdays and avoid additional workload for the staff on weekends, only those patients who underwent surgical procedures on Mondays to Thursdays were included in this study.

Procedure

Observations were made regarding exactly (hour and minute) when targeted breathing exercises of any modality were initiated within the first 24 hours (primary outcome) after arrival on a postoperative ward. The breathing exercises could be started by the patients according to the instructions they had received pre-operatively or started by the staff. The time of initiation and the type of intervention were registered by the attending physiotherapist or nurse. Written instructions with descriptions of the items in the protocol and how to fill it in were sent to the responsible person at each study centre before commencement of the inclusion period. In addition, before each centre started inclusion and during the inclusion period, digital seminars were held which described how the protocol should be used, and questions were answered. The initiation of any type of targeted breathing exercises (DBEs without any specific device, IS, PEP, CPAP or whatever was prescribed) was recorded even if the patient did not fulfil the recommended number or sets of breaths.

Patient characteristics, such as age, smoking history, pulmonary disease, time of surgery and anaesthesia, blood loss, type of anaesthesia, and whether the patient had received pre-operative information from a physiotherapist, were extracted from patient records. Patients were defined as being at high risk of PPCs if they fulfilled any of the following known risk factors: age > 70 years, body mass index > 30 kg/m^2, previously diagnosed with restrictive or obstructive pulmonary disease, smoking (current or ex-smoker for < 6 months), or immobilised.

Early initiation of targeted breathing exercises was defined as within 3 hours after arrival on a postoperative ward after surgery. The 3-hour cut-off was selected arbitrarily, taking into consideration the typical clinical trajectory of recovery following surgery and anaesthesia, and knowledge about the increased risk for development of PPCs with time after surgery.

Statistics

Continuous variables are presented as mean [standard deviation (SD)] or median [interquartile range (IQR)], and categorical variables are presented as number and percentage. Normality of the primary outcome was tested by Kolmogorov–Smirnov test. Differences between the seven different surgical categories were analysed using Kruskal–Wallis test and Wilcoxon signed rank test for continuous variables, and Pearson Chi-squared test for categorical variables. The influence of baseline variables on the proportions of subjects starting specific breathing exercises within 3 hours after arrival on a postoperative ward was analysed with univariate logistic regression. Significant variables from the univariate analyses and sex and age were included in a multivariate logistic regression, where each of the variables was adjusted for all other variables in the model. The result from the logistic regression is given as odds ratio (OR) with 95% confidence interval (CI), and area under the curve is given for the multivariate model. All significance tests were two-sided and conducted at the 5% significance level.

Results

During the inclusion period, a total of 3802 patients were admitted to the postoperative units at the hospitals participating in the study. Of these, 1879 fulfilled the inclusion criteria and 1492 (79%) were included (Fig. 1). The remaining 387 patients (21%) were not included, mainly due to logistic reasons or staff shortages. Demographic data are presented in Table 1. Of the included patients, 52% were men, the average age was 62 (SD 16) years, and they had a median of one risk factor for PPCs. Pre-operative physiotherapy education (either oral, written or video) had been given to 46% (684/1492) of the patients; written information was the most common (Table 1). Written information was given most frequently to patients who underwent major or minor lower abdominal surgery [47/94 (50%) and 138/282 (49%), respectively], and oral information was given most frequently to patients who underwent thoracic surgery (48/94, 51%) or cardiac surgery (118/292, 40%). Details of surgical demographics are presented elsewhere [26].

Information on the number of patients who commenced targeted breathing exercises within 24 hours after arrival on a postoperative ward, when these were initiated,

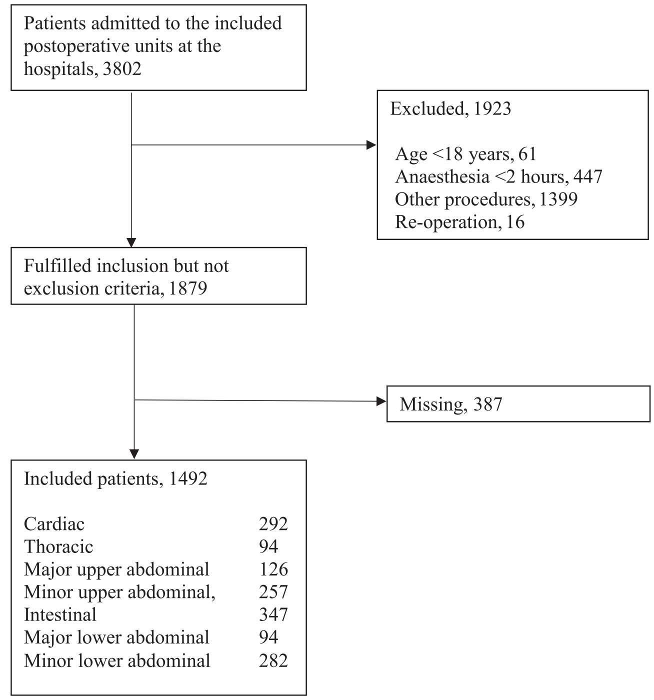

Fig. 1. Study flowchart.

and which specific treatments were performed is presented in Table 2. In total, 1128 of the 1492 patients (76%) performed some form of targeted breathing exercises, and there were significant differences in practice across the seven surgical categories. More patients who underwent cardiothoracic or major abdominal surgery performed these exercises (> 95%) compared with those who underwent minor upper (58%) or lower (54%) abdominal surgery ($P < 0.001$).

The first session of any type of targeted breathing exercise commenced a median of 3.63 hours (IQR 1.58 to 11.75) after arrival on a postoperative ward. The result was not normally distributed (Kolmogorov–Smirnov test 0.206; $P < 0.001$): 50% of the patients started the exercises within 3 hours after arrival on a postoperative ward, 64% within 6 hours, and 24% between 12 and 24 hours. Initiation of exercises differed significantly between the seven surgical categories, and started earliest after minor abdominal surgery and latest after major procedures such as cardiac, pulmonary or major abdominal surgery ($P < 0.001$).

Most patients who performed targeted breathing exercises used PEP ($n = 968/1492$, 65%) or DBEs without any devices ($n = 207/1492$, 14%). PEP was the preferred treatment across all surgical categories, and specifically in categories in which patients underwent major procedures: cardiac, 273/292 (93%); thoracic, 80/94 (85%); and major

Table 1
Demographic data of included patients.

		All, n = 1492	Cardiac n = 292	Thoracic n = 94	Major UA n = 126	Minor UA, n = 257	Intestinal n = 347	Major LA, n = 94	Minor LA, n = 282
Pre-operative factors									
Age, years		62 (16)	64 (14)	60 (18)	67 (13)	56 (18)	67 (16)	62 (14)	59 (15)
Male sex, n		784 (53%)	227 (78%)	49 (52%)	81 (64%)	96 (37%)	175 (50%)	33 (35%)	123 (44%)
BMI, kg/m^2		27.7 (5.5)	27.0 (4.9)	25.7 (4.5)	27.0 (4.8)	29.1 (6.4)	26.3 (5.8)	26.4 (5.1)	27.0 (5.3)
High-risk factors	Age ≥70 years	604 (40%)	122 (42%)	33 (35%)	63 (50%)	78 (30%)	191 (55%)	35 (37%)	82 (29%)
	Pulmonary disease	189 (13%)	31 (11%)	14 (15%)	15 (12%)	40 (16%)	49 (14%)	10 (11%)	30 (11%)
	Current smoking	173 (12%)	37 (13%)	18 (19%)	21 (17%)	21 (8%)	39 (11%)	16 (17%)	21 (7%)
	BMI ≥30 kg/m^2	369 (25%)	70 (24%)	15 (16%)	33 (26%)	95 (37%)	67 (19%)	22 (23%)	67 (24%)
	Immobilised pre-operatively	18 (1%)	2 (1%)	0	1 (1%)	5 (2%)	9 (3%)	0	1 (<1%)
ASA score	1 to 5	2 (1:3)	3 (3:3)	3 (2:3)	2 (2:3)	2 (2:3)	2 (2:3)	2 (2:2)	2 (1:3)
Pre-operative education, n[a]	Written	536 (36%)	93 (33%)	17 (18%)	47 (35%)	62 (24%)	133 (39%)	46 (50%)	138 (50%)
	Oral	359 (24%)	118 (42%)	45 (48%)	40 (32%)	14 (6%)	46 (14%)	35 (37%)	61 (22%)
	Film	23 (1%)	0	0	1 (<1%)	8 (3%)	12 (3%)	1 (1%)	1 (<1%)
	None	787 (53%)	166 (58%)	49 (52%)	73 (58%)	190 (74%)	200 (59%)	47 (50%)	138 (50%)
	Missing	21	8	0	0	2	6	1	4
Peri-operative factors									
Duration of anaesthesia, hours		4.60 (2.17)	4.80 (1.46)	3.66 (1.12)	7.22 (3.12)	3.43 (1.35)	5.26 (2.45)	4.72 (1.81)	3.77 (1.41)
Duration of surgery, hours		3.27 (2.16)	3.41 (1.95)	2.03 (1.07)	5.53 (2.98)	2.33 (1.20)	3.90 (2.29)	3.34 (1.73)	2.59 (1.74)
Type of surgery, n	Open	826 (56%)	282 (97%)	31 (33%)	102 (82%)	68 (27%)	195 (54%)	60 (64%)	88 (31%)
	Minimally invasive, scopic	439 (30%)	9 (3%)	61 (65%)	17 (14%)	184 (72%)	96 (28%)	8 (8%)	64 (23%)
	Minimally invasive, robotic	220 (15%)	0	2 (2%)	6 (5%)	3 (1%)	54 (16%)	26 (28%)	129 (46%)
	Missing	7	1	0	1	2	2	0	1
Surgery, n	Elective	1280 (86%)	222 (76%)	85 (90%)	121 (97%)	232 (91%)	231 (94%)	93 (100%)	276 (99%)
	Acute	203 (14%)	70 (24%)	9 (10%)	4 (3%)	23 (9%)	14 (6%)	0	3 (1%)
	Missing	9	0	0	1	2	2	1	3

LA, lower abdominal; UA, upper abdominal; BMI, body mass index; ASA, American Society of Anesthesiologists.
Data are mean (standard deviation), median (interquartile range) or n (%).
[a] More than one registration possible.

Table 2
Time that breathing exercises commenced after arrival on a postoperative ward and modality used by category of surgery.

		All, n = 1492	Cardiac n = 292	Thoracic n = 94	Major UA n = 126	Minor UA, n = 257	Intestinal n = 347	Major LA n = 94	Minor LA n = 282	P-value
Time to start of targeted breathing exercises, hours		3.63 (1.58 to 11.75)	5.67 (2.67 to 10.85)	4.25 (2.50 to 15 to 92)	4.04 (2.17 to 13.97)	2.10 (1.00 to 6.02)	2.67 (1.33 to 12.38)	3.60 (1.42 to 16.98)	2.33 (1.25 to 7.75)	<0.001
Within 3 hours after arrival on a postoperative ward, n		467 (31%)	71 (24%)	28 (30%)	41 (32%)	80 (31%)	135 (39%)	28 (30%)	84 (30%)	<0.001
Within 24 hours after arrival on a postoperative ward, n	No, n	364 (24%)	14 (5%)	6 (6%)	12 (10%)	108 (42%)	69 (20%)	29 (31%)	130 (46%)	<0.001
	Yes, n	1128 (76%)	278 (95%)	88 (94%)	114 (90%)	149 (58%)	278 (80%)	65 (69%)	152 (54%)	
Breathing exercises performed	Deep breathing without a device	207 (14%)	6 (2%)	10 (11%)	10 (8%)	48 (19%)	76 (22%)	19 (20%)	38 (13%)	<0.001
	PLB	9 (<1%)	0	1 (1%)	2 (2%)	3 (1%)	0	1 (1%)	2 (<1%)	0.194
	PEP	968 (65%)	273 (93%)	80 (85%)	105 (83%)	101 (39%)	232 (67%)	57 (61%)	120 (43%)	<0.001
	NIV	6 (<1%)	0	0	0	1 (<1%)	3 (<1%)	0	2 (<1%)	0.511
	Not defined	2 (<1%)	2 (2%)	0	0	0	0	0	0	n.a.

NIV, non-invasive ventilation; LA, lower abdominal; PEP, positive expiratory pressure; PLB, pursed lips breathing; UA, upper abdominal.
Data are median (interquartile range) or n (%).

Fig. 2. Number of participants arriving in postoperative care and number of participants starting breathing exercises during the day and night.

upper abdominal, 105/126 (83%) (P < 0.001). The use of DBEs without any devices also differed between the seven surgical categories, and was more common after minor and/or lower abdominal surgery: intestinal, 76/347 (22%); major lower abdominal surgery, 19/94 (20%); minor upper abdominal surgery, 48/257 (19%); and minor lower abdominal surgery, 38/282 (13%) (P < 0.001) (Table 2). Pursed lips breathing and non-invasive ventilation were seldom used.

The exact time of arrival on the postoperative ward after surgery and the time when targeted breathing exercises started are presented in Fig. 2. A large discrepancy in initiation of breathing exercises was found, dependent upon time of arrival on the postoperative ward. Most patients arrived in the daytime, between 11 a.m. and 5 p.m., and the targeted breathing exercises were most often initiated between 8 a.m. and 8 p.m. This means that patients who arrived on the ward after surgery during the later part of the day did not start targeted breathing exercises until the following day.

The results of the univariate and multivariate analyses for the commencement of targeted breathing exercises within 3 hours after arrival on a postoperative ward are presented in Table 3 and Fig. 3. According to the multivariate model, the odds of initiating breathing exercises within 3 hours after arrival on a postoperative ward were higher if a patient underwent thoracic or abdominal surgery (OR > 2.04, P < 0.001), or had intravenous analgesia (OR 1.50, 95% CI 1.05 to 2.14; P = 0.026). The odds of initiating breathing exercises within 3 hours after arrival on a postoperative ward were lower in patients who arrived on the postoperative ward in the evening/night (OR 0.43, 95% CI 0.21 to 0.88; P = 0.021) or had undergone laparoscopic surgery (OR 0.63, 0.43-0.92, p=0.018).

Table 3
Odds ratio for start of breathing exercises within three hours after surgery. Both in univariable models and in a multivariable model with all significant univariable variables and included sex and age.

		n (%) of event	OR (95%CI)	*p-value*	Adjusted OR (95%CI)	Adjusted *p-value*
Sex	Male	244 (41)	1.18 (0.92-1.50)	0.18	0.81(0.60-1.08)	0.15
	Female	221 (45)				
Age, years	18- < 59	142 (43)	1.01(0.93-1.09)	0.84	1.04 (0.95-1.14)	0.44
	59- < 73	172 (45)				
	73-95	152 (42)				
Obesity	BMI < 30 kg/m^2	319 (41)	1.38 (1.05-1.82)	0.020	1.36 (0.99-1.86)	0.055
	≥30 kg/m^2	140 (49)				
Smoker	Non smoker	415 (44)	0.91 (0.63-1.33)	0.64		
	Current smoker	52 (41)				
Physical function	Not dependant	465 (43)	0.33 (0.07-1.54)	0.16		
	Dependant	2 (20)				
Pulmonary disease	None	395 (42)	1.33 (0.94-1.89)	0.11		
	Diagnosed	72 (49)				
Risk of PPC	Low risk PPC	137 (40)	1.17 (0.90-1.52)	0.23		
	High risk of PPC	330 (44)				
Preoperative information	Non	260 (48)	0.62 (0.49-0.80)	< 0.001	0.78 (0.58-1.06)	0.12
	Yes	195 (37)				
Surgery	Elective vs elective	384 (45)	1.00	0.029[a]	1.00	0.24[a]
	Acute vs elective	49 (40)	0.82 (0.56-1.21)	0.32	0.63 (0.37-1.08)	0.093
	Subacute vs elective	31 (31)	0.56 (0.36-0.87)	0.011	0.87 (0.50-1.52)	0.63
Type of surgery	Cardiac vs. Cardiac	71 (26)	1.00	< 0.001[a]	1.00	< 0.001[a]
	Thoracic vs Cardiac	29 (33)	1.38 (0.82-2.31)	0.23	2.61 (1.34-5.10)	0.005
	Major upper abd vs Cardiac	41 (38)	1.74 (1.08-2.80)	0.022	2.04 (1.18-3.53	0.011
	Minor upper abd vs. Cardiac	79 (57)	3.81 (2.47-5.87)	< 0.001	5.34 (2.83-10.07)	< 0.001
	Intestinal vs. Cardiac	135 (52)	3.05 (2.12-4.38)	< 0.001	3.81 (2.26-6.41)	< 0.001
	Major Lower Abd vs. Cardiac	28 (43)	2.15 (1.23-3.77)	0.007	2.73 (1.36-5.51)	0.005
	Minor Lower Abd vs. Cardiac	84 (57)	3.79 (2.48-5.80)	< 0.001	5.11 (2.75-9.49)	< 0.001
Procedure	Open	226 (55)	0.45 (0.35-0.58)	< 0.001	0.63 (0.43-0.92)	0.018
	Laparoscopic	226 (55)				
	Laparoscopic with robot	83 (58)	2.04 (1.43-2.92)	< 0.001	0.88 (0.52-1.50)	0.64
	No robot	381 (41)				
Duration anaesthesia, hours	2.00- < 3.45	152 (49)	0.76 (0.58-1.00)	0.053		
	3.45- < 4.85	137 (38)				
	4.85-20.12	175 (44)				
Arrival to postop	Day vs. day	230 (47)	1.000	0.016[a]	1.00	0.015[a]
	Evening vs Day	219 (41)	0.79 (0.62-1.01)		0.71 (0.53-0.95)	0.021
	Night vs Day	18 (30)	0.47 (0.26-0.84)		0.43 (0.21-0.88)	0.021
Analgesia	Intravenous	385 (47)	2.06 (1.53-2.77)	< 0.001	1.50 (1.05-2.14)	0.026
	No intravenous	79 (30)				
	Epidural	98 (43)	1.02 (0.75-1.36)	0.92		
	No epidural	360 (43)				
	Spinal	66 (58)	2.02 (1.36-2.99)	0.001	1.32 (0.81-2.16	0.26
	No spinal	393 (41)				
Type of ward	IMU vs. IMU	7 (18)	1.00	0.004[a]	1.00	< 0.001[a]
	Postp/ICU vs IMU	308 (46)	3.75 (1.63-8.63)	0.002	3.72 (1.43-9.68)	0.007
	Surgical ward vs. IMU	137 (41)	3.05 (1.30-7.12)	0.010	1.49 (0.58-3.85)	0.41

Table 3 (*Continued*)

		n (%) of event	OR (95%CI)	*p-value*	Adjusted OR (95%CI)	Adjusted *p-value*
Type of hospital	University vs university	288 (38)	1.00	< 0.001	1.00	0.98[a]
	Regional county vs. university	153 (53)	1.84 (1.39-2.42)	< 0.001	0.97 (0.66-1.44)	0.88
	Local county vs university	26 (60)	2.46 (1.31-4.61)	0.005	0.93 (0.44-1.94)	0.84

CI, confidence interval; BMI, body mass index; PPC, postoperative pulmonary complication; ICU, intensive care unit; IMU, intermediate unit.
P-values, OR and Area under ROC-curve are based on original values and not on stratified groups. OR is the ratio for the odds for an increase of the predictor of one unit. All tests are performed with univariable logistic regression.
Area under the ROC curve (AUC) for the multivariable logistic model = 0.71
[a] *p*-value for the entire effect/factor/variable. In the multivariable analysis each variable is adjusted for all other variables in the model. OR for Age is given per 10 years.

Discussion

To the authors' knowledge, this is the first national observational study to record clinical practice regarding breathing exercises after abdominal and cardiothoracic surgery prospectively. The results reveal unique information which is useful for comparison with other countries. Of the 1492 included patients, 76% performed targeted breathing exercises within 24 hours after arrival on a postoperative ward. This proportion was higher in patients who had undergone major abdominal or cardiothoracic surgery. According to national guidelines, prophylactic breathing exercises in the early postoperative period are recommended [25,27], and this study showed good adherence to these guidelines.

As lung function is negatively affected by anaesthesia and surgery, the aims of breathing exercises are to enhance recovery and avoid PPCs [28]. Why patients undergoing major procedures did not start breathing exercises sooner may be questioned. Longer procedures resulted in later arrival on the postoperative ward, when there are fewer staff. It is also possible that the patients needed longer to fully awaken, and able to remember the pre-operative instructions and cooperate fully with the healthcare staff. As well as the impact of the length of surgery, patients with pre-operative risk factors, such as smoking history, pulmonary disease or older age, may also benefit from starting prophylactic breathing exercises earlier, and previous trials have shown a dose-related response to earlier initiation and higher frequency of breathing exercises, thereby improving oxygenation and reducing atelectasis [29,30].

As seen in Fig. 2, most patients arrived on the postoperative ward between 11:00 a.m. and 5 p.m., and targeted breathing exercises were initiated mainly between 8 a.m. and 8 p.m. It was rare to start any breathing exercises during the night. This may be interpreted as meaning that patients arriving in the later part of the afternoon did not start their breathing exercises until the following morning, irrespective of whether they had undergone a longer procedure or had several risk factors for developing PPCs. This was confirmed by the multivariate analysis, where the odds of initiating targeted breathing exercises within 3 hours after arrival on a postoperative ward were lower for patients who arrived on the postoperative ward in the evening/night. In Swedish hospitals, physiotherapeutic services are not normally provided outside office hours. As patients often arrive on the postoperative ward later in the afternoon, prolonged working hours may need to be considered in order to initiate breathing exercises earlier, especially for those at high risk of developing PPCs. This would allow equal care to be given to all patients, and would increase adherence to the evidence-based clinical guidelines.

The odds of starting targeted breathing exercises within 3 hours after arrival on a postoperative ward were higher if a patient underwent thoracic or abdominal surgery, or had intravenous analgesia. It is possible that patients who undergo these types of surgery and who have postoperative pain managed with intravenous analgesia recover more quickly, and thus start their breathing exercises earlier.

While the initiation of lung expansion manoeuvres remains a priority objective for physiotherapeutic interventions for patients following major surgery, the methods of delivering these are known to vary. Previous Swedish surveys have shown that PEP is predominantly used following abdominal and cardiac surgery [13,24], and this was also found in the present study. However, PEP is not the first choice of treatment in all parts of the world. Surveys from other countries have shown that DBEs with or without devices, pursed lips breathing or ACBTs are primarily used [11,16–18]. The aim of PEP postoperatively is to increase functional residual capacity and tidal volume, both of which are known to be decreased postoperatively [29]. The effect is seen within a few breaths and may, if used correctly, contribute to reduce the incidence of PPCs [26,31–33]. The aim of DBEs without or with devices such as IS may also increase tidal volume, but not functional residual capacity. However, even if breathing exercises are beneficial in postoperative care, it is important to prescribe person-centred treatment to optimise their effect. The use of routine prescriptions should be avoided.

This part of the SOMBATA study focused on targeted breathing exercises after surgery. Other important interventions commonly used postoperatively include mobilisation and positioning. An upright position increases functional residual capacity, in parity with or exceeding the effects of specific breathing interventions [33,34]. In cardiorespiratory physiotherapy, both are used in parallel.

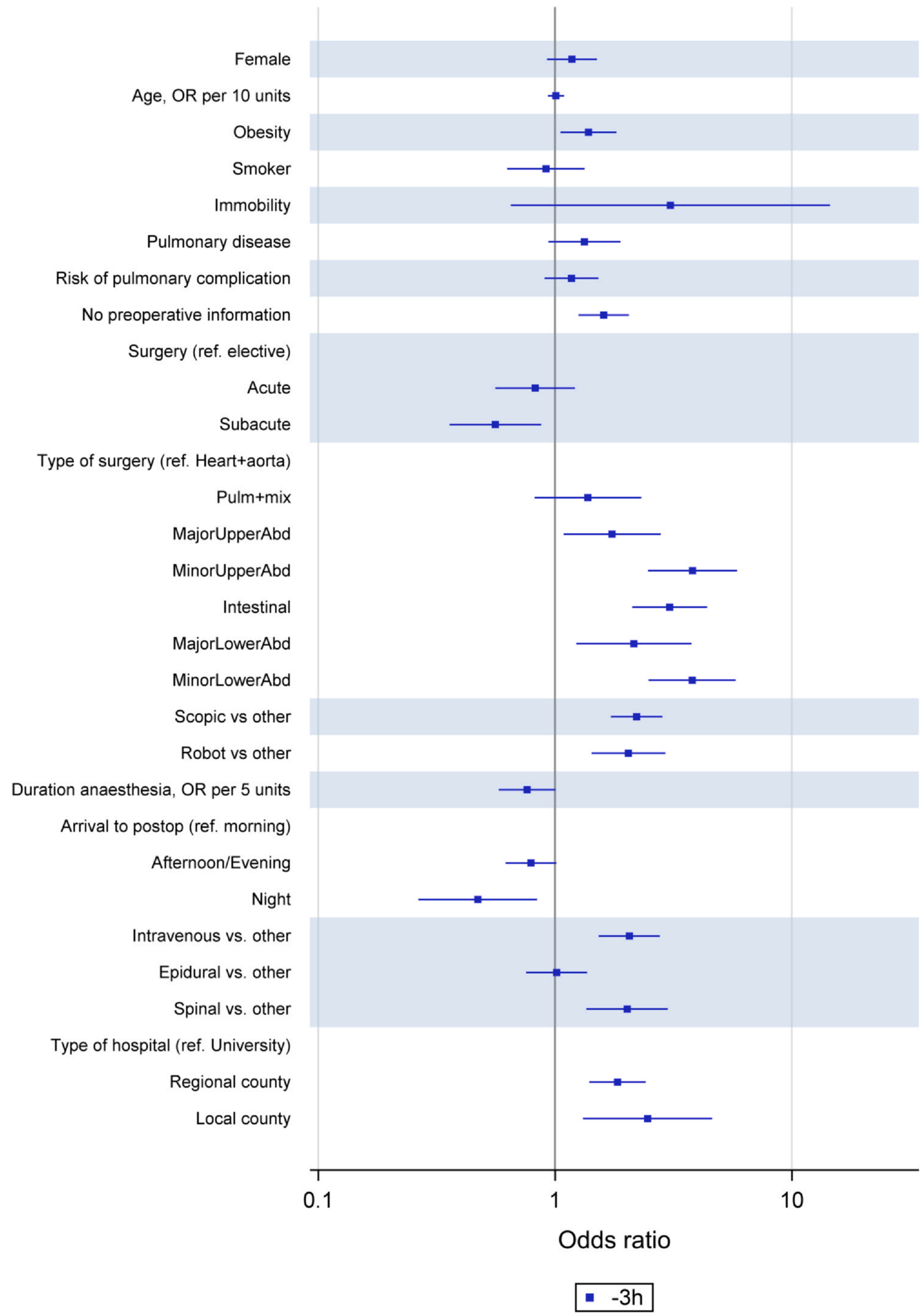

Fig. 3. Forest plot for odds of starting breathing exercises within 3 hours of end of surgery. OR, odds ratio.

Mobilisation is the first choice of treatment, and breathing exercises may be more useful after major surgery and for patients at higher risk of developing PPCs.

This study has both limitations and strengths. One limitation is that only a few county hospitals took part despite being invited, while all university hospitals participated. Nonetheless, the participating hospitals represented all parts of the country. A further limitation is that while the authors intended to capture the timing and type of first targeted breathing exercise intervention, it is possible that a few patients started earlier than noticed by the staff. No evaluations of the reliability of registration were performed, but written instructions were given in addition to the protocol, and digital seminars were held before and during the inclusion period to provide information about how to register the data. This study was not preceded by any power calculation as there was limited knowledge of the subject. However, it was estimated that > 500 patients would be needed to perform subgroup and probability analyses. The number of included patients exceeded the estimations, and therefore made it possible to perform the planned analyses. In addition, as only those patients undergoing procedures from Mondays to Thursdays were included, clinical practice over the weekends was not captured.

In conclusion, the results from this national study show that 76% of the patients undergoing abdominal or cardiothoracic surgery started targeted breathing exercises a median of 3.63 hours after arrival on a postoperative ward. While guidelines recommend commencing breathing exercises early after surgery, no previous studies have investigated this practice. An overview of the practice in a country such as Sweden reveals unique baseline information, and this will be useful for comparison with other countries.

Ethical approval: The study protocol was approved by the Swedish Ethical Review Authority (Registration no. 2020-03108).

Funding: Work was supported by grants from the Swedish state under the agreement between the Swedish Government and the county councils: the ALF Agreement (ALFGBG-965563).

Conflict of interest:

None declared.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.physio.2024.101462.

References

[1] Canet J, Gallart L, Gomar C, Paluzie G, Vallès J, Castillo J, *et al.* Prediction of postoperative pulmonary complications in a population-based surgical cohort. Anesthesiology 2010;113:1338–50.

[2] Lakshminarasimhachar A, Smetana GW. Preoperative evaluation: estimation of pulmonary risk. Anesth Clin 2016;34:71–88.

[3] Katsura M, Kuriyama A, Takeshima T, Fukuhara S, Furukawa TA. Preoperative inspiratory muscle training for postoperative pulmonary complications in adults undergoing cardiac and major abdominal surgery. Cochrane Database Syst Rev 2015;2015:CD010356.

[4] 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. Eur J Trauma Emerg Surg 2021;47:975–90.

[5] do Nascimento Junior P, Módolo NS, Andrade S, Guimarães MM, Braz LG, El Dib R. Incentive spirometry for prevention of postoperative pulmonary complications in upper abdominal surgery. Cochrane Database Syst Rev 2014;2014:CD006058.

[6] Kendall F, Abreu P, Pinho P, Oliveira J, Bastos P. The role of physiotherapy in patients undergoing pulmonary surgery for lung cancer. A literature review. Rev Port Pneumol 2017;23:343–51.

[7] Pasquina P, Tramèr MR, Granier JM, Walder B. Respiratory physiotherapy to prevent pulmonary complications after abdominal surgery: a systematic review. Chest 2006;130:1887–99.

[8] Pasquina P, Tramèr MR, Walder B. Prophylactic respiratory physiotherapy after cardiac surgery: systematic review. BMJ 2003;327:1379.

[9] Sullivan KA, Churchill IF, Hylton DA, Hanna WC. Use of incentive spirometry in adults following cardiac, thoracic, and upper abdominal surgery to prevent post-operative pulmonary complications: a systematic review and meta-analysis. Respiration 2021;100:1114–27.

[10] Hanekom SD, Brooks D, Denehy L, Fagevik-Olsén 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 Med Inf Decis Mak 2012;12:5.

[11] Aldhuhoori FZ, Walton LM, Bairapareddy KC, Amaravadi SK, Alaparthi GK. Physiotherapy practice for management of patients undergoing upper abdominal surgery in United Arab Emirates – a national survey. J Multidiscip Health 2021;14:2513–26.

[12] Filbay SR, Hayes K, Holland AE. Physiotherapy for patients following coronary artery bypass graft (CABG) surgery: limited uptake of evidence into practice. Physiother Theory Pract 2012;28:178–87.

[13] 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 Anesth Clin Res 2013;4:6.

[14] Jonsson M, Westerdahl E, Reeve J. Physiotherapy provided for patients undergoing thoracic surgery in Sweden – a national survey of practice. Physiother Theory Pract 2024;40:2179–85.

[15] O'Donohue Jr WJ. National survey of the usage of lung expansion modalities for the prevention and treatment of postoperative atelectasis following abdominal and thoracic surgery. Chest 1985;87:76–80.

[16] Overend TJ, Anderson CM, Jackson J, Lucy SD, Prendergast M, Sinclair S. Physical therapy management for adult patients undergoing cardiac surgery: a Canadian practice survey. Physiother Can 2010;62:215–21.

[17] Patman S, Bartley A, Ferraz A, Bunting C. Physiotherapy in upper abdominal surgery – what is current practice in Australia? Arch Physiother 2017;7:11.

[18] Reeve J, Anderson L, Raslan Y, Grieve C, Ford J, Wilson L. The physiotherapy management of patients undergoing abdominal surgery: a survey of current practice. N Z J Physiother 2019;47:66–75.

[19] Reeve J, Denehy L, Stiller K. The physiotherapy management of patients undergoing thoracic surgery: a survey of current practice in Australia and New Zealand. Physiother Res Int 2007;12:59–71.

[20] Reeve J, Ewan S. The physiotherapy management of the coronary artery bypass graft patient: a survey of current practice throughout the United Kingdom. J Assoc Chart Physiother Respir Care 2005;37:35–45.

[21] Scoles R, Denehy L, Sztendur E, Browning L. A survey of Australian physiotherapy management of patients having abdominal surgery. Aust J Physiother 2006;52:S26–7.

[22] Tucker B, Jenkins S, Davies K, McGann R, Waddell J, King R, *et al.* The physiotherapy management of patients undergoing coronary artery surgery: a questionnaire survey. Aust J Physiother 1996;42:129–37.

[23] van Beijsterveld CA, Heldens AF, Bongers BC, van Meeteren NL. Variation in preoperative and postoperative physical therapist management of patients opting for elective abdominal surgery. Phys Ther 2019;99:1291–303.

[24] Westerdahl E, Olsen MF. Chest physiotherapy and breathing exercises for cardiac surgery patients in Sweden – a national survey of practice. Monaldi Arch Chest Dis 2011;75:112–9.
[25] Hillman M, Fagevik Olsen M, Johansson H, Sandström L, Westerdahl E. Guidelines for respiratory physiotherapy for patient undergoing abdominal and cardiothoracic surgery Internet. Fysioterapeuterna 2018 [Available at: ⟨https://www.fysioterapeuterna.se/globalassets/professionsutveckling/kliniska-riktlinjer/dokument/riktlinjer-resp-vid-kir-uppdatering-1812-2019.pdf⟩ last accessed September 2023].
[26] Fagevik Olsén M, Sehlin M, Westerdahl E, Schandl A, Block L, Nygren-Bonnier M, *et al.* First mobilisation aftger abdominal and cardiothoracic surgery: when is it actually performed? A national, multicentee, cross-sectional study. BMJ Open 2024;14:e082239.
[27] Melloul E, Hübner M, Scott M, Snowden C, Prentis J, Dejong CH, *et al.* Guidelines for perioperative care for liver surgery: enhanced recovery after surgery (ERAS) society recommendations. World J Surg 2016;40:2425–40.
[28] Fagevik Olsén M. Chest physical therapy in surgery: a theoretical model about who to treat. Breathe 2005;1:308–14.
[29] Eltorai AEM, Baird GL, Eltorai AS, Healey TT, Agarwal S, Ventetuolo CE, *et al.* Effect of an incentive spirometer patient reminder after coronary artery bypass grafting: a randomized clinical trial. JAMA Surg 2019;154:579–88.
[30] 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. Eur J Cardiothorac Surg 2011;40:162–7.
[31] Fagevik Olsen M, Lannefors L, Westerdahl E. Positive expiratory pressure – common clinical applications and physiological effects. Respir Med 2015;109:297–307.
[32] Fagevik Olsen M, Larsson M. Breathing exercises with PEP – what happens to the breathing pattern during a session? Nord Fysioter 2005;9:195–200.
[33] Lumb A. Respiratory system resistance. Thomas C. Nunn and Lumb's applied respiratory physiology. 9th ed.London: Elsevier; 2021. p. 27–41.
[34] Lumb A. Elastic forces and lung volumes. Thomas C. Nunn and Lumb's applied respiratory physiology. 9th ed.London: Elsevier; 2021. p. 14–26.