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PHYSIO+++: protocol for a pilot randomised controlled trial assessing the feasibility of physiotherapist-led non-invasive ventilation for patients with hypoxaemia following abdominal surgery

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ABSTRACT

Introduction Few clinical trials have investigated physiotherapy interventions to treat hypoxaemia following abdominal surgery. The objective of this study is to determine the feasibility and safety of conducting a clinical trial of physiotherapist-led non-invasive ventilation (NIV).

Methods and analysis This single-centre, 50-patient, parallel-group, assessor blinded, pilot feasibility randomised controlled trial with concealed allocation will enrol spontaneously ventilating adults with hypoxaemia within 72 hours of major abdominal surgery. Participants will receive either (1) usual care physiotherapy of a single education session (talk), daily walking of 10–15 min (walk) and four sessions of coached deep breathing and coughing (breathe) or (2) usual care physiotherapy plus four 30 min sessions of physiotherapist-led NIV delivered over 2 postoperative days. Primary feasibility and safety outcome measures are; number of eligible patients recruited per week, total time of NIV treatment delivered, acceptability of treatments to patients and clinicians and incidence of adverse events. Secondary feasibility outcomes include measures of recruitment and treatment adherence. Exploratory outcome measures include change in respiratory parameters, postoperative pulmonary complications, length of hospital stay, health-related quality of life, postoperative activity levels and mortality.

Ethics and dissemination Ethics approval has been obtained from the relevant institution. Results will be published to inform future research.

Trial registration number ACTRN12622000839707.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ No previous physiotherapy study has assessed an intervention to manage hypoxaemia following abdominal surgery.
⇒ A novel non-invasive bedside assessment, The Air Test 90, will be used to detect hypoxaemia.
⇒ This pragmatic study standardises accepted physiotherapy interventions (talk, walk, breathe) as an active control.
⇒ Assesses perspectives of participants and clinicians regarding the interventions.
⇒ This feasibility study is not powered to assess treatment efficacy.

INTRODUCTION

Hypoxaemia in the early postoperative period following major abdominal surgery is common in the first 3 postoperative days,[1] occurring in up to 65% of patients.[1–4] Persistent hypoxaemia can lead to serious postoperative pulmonary complications (PPC) including respiratory failure, admission to intensive care for mechanical ventilation, high hospital resource utilisation, prolonged length of stay and increased risk of mortality.[1 2 4–8]

Patient education (talk), early walking (walk) and breathing exercises (breathe) are routinely provided by physiotherapists with an aim to prevent hypoxaemia, minimise PPCs, and facilitate functional recovery following major abdominal surgery.[9 10] However, for patients who develop hypoxaemia, additional therapies are indicated.[10 11] Non-invasive ventilation (NIV) is recommended to treat postoperative hypoxaemia as it can improve oxygenation, reduce atelectasis, reduce pneumonia, avoid reintubation and reduce mortality compared with conventional oxygen therapy.[10 12 13] NIV is commonly applied for at least an hour continuously[14] in intensive care units (ICUs) or high-dependency units. However, NIV may not be routinely and rapidly available for those with postoperative hypoxaemia on surgical wards. This

may be due to issues with staff resourcing, expertise, or levels of patient monitoring.[15 16] Physiotherapists supervising shorter sessions of NIV on surgical wards may be an option to fill this gap.

The safety and feasibility of physiotherapist-led NIV has been established following high risk abdominal surgery[17] and in intensive care following cardiac surgery for patients with hypoxaemia.[18] However, it is uncertain if physiotherapist-led NIV is safe and feasible in major abdominal surgery patients who develop hypoxaemia while on a surgical ward.

A large multicentre randomised controlled trial is needed to test the efficacy of physiotherapist-led sessional NIV to improve outcomes for patients with postoperative hypoxaemia. However, prior to conducting a definitive trial testing clinical efficacy, a pilot study is required to assess trial processes including the feasibility, safety and fidelity of physiotherapist-led NIV in patients with hypoxaemia following abdominal surgery. This pilot study will provide evidence to guide future research.

Objectives

The objectives of this pilot study are to assess: (1) the feasibility of recruiting patients who develop hypoxaemia within 72 hours of abdominal surgery into a physiotherapy clinical trial, (2) adherence to protocolised treatments, (3) participant and clinician acceptability of treatments and (4) the safety of physiotherapy treatments for patients who have developed hypoxaemia following abdominal surgery.

METHODS AND ANALYSIS

Study design

PHYSIOtherapy management for hypoxaemia following abdominal surgery: talk+walk+breathe+NIV (PHYSIO+++) is a pragmatic, prospective, single-centre, assessor blinded, parallel group, exploratory, pilot, randomised controlled trial. Patients will be randomly assigned via concealed allocation to either an active control (talk, walk, breathe) or intervention (talk, walk, breathe and NIV). The PHYSIO+++ protocol is reported in line with the Standard Protocol Items: Recommendations for Interventional Trials 2022 guidelines.[19] Figure 1 outlines the planned participant flow through the trial using the Consolidated Standards of Reporting Trials diagram.[20]

Patient and public involvement

PHYSIO+++ was designed with consumer (LH) contributions to protocol development, participant survey design and manuscript preparation. PHYSIO+++ will explore participant perceptions of the acceptability of physiotherapy interventions aimed at treating their hypoxaemia. These findings will support future trial design, as guided by patient experiences and values.

Study setting

Surgical wards and an ICU within an Australian government-funded, metropolitan, quaternary, university-affiliated, teaching hospital.

Participants and enrolment

The prior day's theatre list, surgical ward and ICU admissions will be screened daily by the research team for

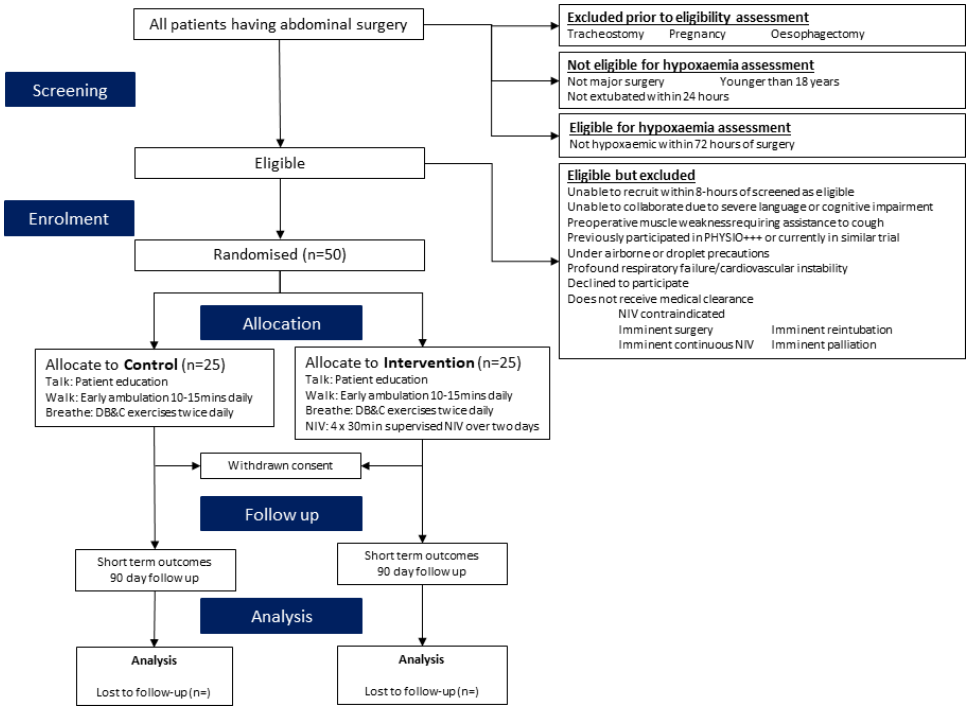

Figure 1 CONSORT flow diagram for the PHYSIO+++ study. CONSORT, Consolidated Standards of Reporting Trials; DB&C, deep breathing and cough; NIV, non-invasive ventilation.

eligible patients. Admission, operation and postoperative details will be reviewed to confirm eligibility against the inclusion and exclusion criteria. Identified patients will be screened for hypoxaemia by a physiotherapist at least once every 24 hours, starting from 4 hours and up to 72 hours after anaesthetic stop time as recorded in the medical record. Day 0 is the day the operation started. Midnight is the start of a new day.

Assessment for hypoxaemia

Intentional removal of prescribed oxygen therapy during measurement of peripheral oxyhaemoglobin saturations (SpO_2) has previously been used as a proxy measure for atelectasis in postoperative populations[21] and can predict poor outcomes.[22]

Hypoxaemia, in this study, will be diagnosed at the bedside with the Air Test 90. To conduct The Air Test 90, the screening clinician will remove the conventional or high flow oxygen therapy device (HFOT) for a maximum of 2 min while continuously monitoring SpO_2 using a finger probe attachment. A Welch-Allyn Connex Vital Signs Monitor pulse oximeter will be used on surgical wards and a Phillips IntelliVue MX850 monitor in ICU. An SpO_2<90% measured on air is diagnostic of hypoxaemia. Oxygen therapy will be reapplied immediately after 2 min or if hypoxaemia is detected, whichever occurs first. Due to local protocols, those in ICU with a FiO_2 between 0.3 and 0.5, a stepped reduction in FiO_2 will precede complete removal of the oxygen therapy device. If the patient has been prescribed oxygen therapy with an FiO_2≥0.5, the Air Test 90 will not be conducted and hypoxaemia automatically diagnosed. In cases where the Air Test 90 is not able to be performed (respiratory rate >25, clinician concern), the most recent ratio of partial pressure of oxygen to fraction of inspired oxygen (P/F ratio) from an arterial blood gas taken postextubation and within the preceding 3 hours of screening will be assessed if available with a P/F ratio <300 diagnostic of hypoxaemia. All physiotherapists involved in the identification of eligible patients will be trained in the standardised screening procedures and in conducting the Air Test 90.

Following diagnosis of hypoxaemia, a trial physiotherapist will discuss suitability of the potential participant with the treating medical officer to confirm the absence of any exclusion criteria.

Eligibility criteria

Inclusions

- Major elective or emergency abdominal surgery via an open (≥5 cm) abdominal incision, laparoscopic or robotic incision with an anaesthetic time ≥3 hours.
- Extubated within 24 hours of surgery completion.
- Breathing without NIV/continuous positive airway pressure (CPAP).
- Age ≥18 years at time of surgery.
- Hypoxaemia at least 3 hours after extubation and within 72 hours of surgery.

Exclusions

- Non-consent to participate in study
- Unable to understand English without an interpreter
- Severe cognitive impairment
- Pregnancy
- Oesophagectomy
- Presence of a tracheostomy or other artificial airway
- Previously participated in PHYSIO+++
- Current enrolment in a trial with similar treatments or outcomes
- Patients under airborne or droplet precautions
- Premorbid neuromuscular condition with significant muscle weakness necessitating manual or mechanical assistance to cough
- Not able to be recruited within 8 hours of being assessed as eligible to enter the trial
- NIV or CPAP for premorbid sleep disordered breathing utilised during hospital admission
- Does not receive medical clearance to participate in the trial due to:

a. Imminent (anticipated within 12 hours of study inclusion) surgery, palliation, reintubation or the need for continuous medically prescribed NIV/CPAP
b. Profound respiratory failure or cardiovascular instability
c. NIV contraindicated (online supplemental table 1)

Consent process

Eligible patients will be approached for informed consent at the bedside by a member of the research team. The patient will be provided verbal (standardised script) and written (patient information and consent form) information about the clinical trial and invited to participate (online supplemental file 1—participant information and consent form). If the patient is unable to provide informed consent due to postoperative delirium, distress or pain, a substitute decision maker will be contacted either face to face or via telephone and provided with verbal and written information regarding the trial (online supplemental file 2—substitute decision-maker information and consent form). Where a substitute decision-maker provides verbal consent by telephone, this will be followed by written consent as soon as possible.

If an eligible patient is unable to provide consent and their substitute decision-maker is not immediately contactable, the patient will be randomised and recruited into the trial prior to consent, as approved by the hospital's ethics committee. Information about the trial will be provided to the participant or substitute decision maker as soon as possible during the hospital admission and the option to withdraw from the trial provided. This approach to consent aligns with established Australian guidelines for research conduct for people highly dependent on medical care who may be unable to give consent[23] and where timely delivery of treatment is important. Qualitative research has found patients having emergency laparotomy within a physiotherapy treatment trial prefer an enrolment prior to consent model.[9]

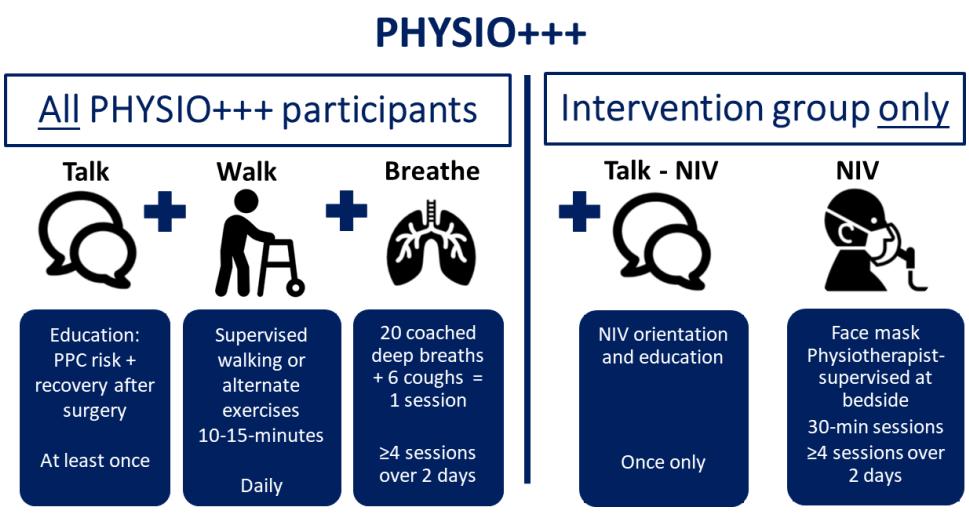

Figure 2 PHYSIO+++ protocolised treatments. NIV, non-invasive ventilation; PPC, postoperative pulmonary complications.

Procedures

Protocolised trial treatments will be provided by physiotherapists with training and experience in all elements of the protocol. Participants will receive the protocolised physiotherapy treatment from day of enrolment until any one of the following endpoints are met: (1) the eighth postoperative day, (2) from the second postoperative day if a readiness for discharge from physiotherapy threshold score is met (online supplemental table 2),[24] (3) patient is reintubated for further surgery, (4) patient is discharged from hospital, transferred to another facility, is for comfort cares, for immediate palliation or dies or (5) breathing support is escalated by a medical team as defined by the need for tracheal intubation and invasive mechanical ventilation or prescribed continuous NIV/CPAP. Continuous NIV/CPAP will be defined as an intended duration of therapy greater than 1 hour in a single session.[14]

Once an endpoint is met, study treatment protocols cease and the participant will receive ongoing physiotherapy treatments at the discretion of the ward physiotherapist. As per standard of care, any clinical deterioration will be managed by the treating medical team.

Interventions

Active control group: talk+walk+breathe

All participants will receive physiotherapy treatments typically delivered in Australian hospitals. PHYSIO+++ treatment protocols are described in figure 2 and in the PHYSIO+++ Template for Intervention Description and Replication[25] (online supplemental table 3).

Talk

As soon as the participant is alert enough to receive instructions, a verbal education session regarding prevention of PPC, early walking and breathing exercises will be provided by a physiotherapist, as previously described.[26] To consolidate verbal information, a booklet containing written and pictorial information will be provided. The booklet is adapted from those previously tested for patient acceptability and readability in trials of similar patient populations.[27] Education sessions may be repeated at the treating physiotherapist's discretion if they believe the participant is unable to recall the information or is not motivated to participate in early walking and breathing exercises.

Walk

Participants will be provided with physiotherapist-supervised walking away from the bedside for at least 10 min and no more than 15 min once daily. If a participant is unable to participate in upright walking, then non-walking physical rehabilitation exercises will be provided in a previously described[26] sequential step-down process starting with the highest activity possible and moving to less intense (online supplemental figure 1).

Breathe

Participants will receive supervised coached deep breathing and coughing exercises performed in upright sitting for a minimum of four treatment sessions over 2 days. Additional coached breathe sessions may be delivered at the treating physiotherapist's discretion.

Intervention group only

Talk – NIV

Participants in the intervention group will receive an additional single education session regarding NIV treatment including orientation to the NIV machine, circuit and interface as well as the reasons for and potential benefits of NIV.

Non-invasive ventilation

Bilevel NIV via face mask will be provided by a physiotherapist for at least four 30 min sessions over 2 days. NIV will be delivered with a ResMed VPAP S9 machine and a ResMed AcuCare F 1–1 non-vented face mask (ResMed, Oxfordshire, UK). Spontaneous/timed mode will be selected for bilevel NIV application. Expiratory positive airway pressure will start then progress from 5 to 10 cm

of water and inspiratory positive airway pressure (IPAP) 10–15 cm of water. See full detailed description in online supplemental table 3. Additional NIV sessions may be delivered. The reason, count and duration of additional sessions will be recorded and reported.

Concomitant care: not protocolised

Although many surgical teams at the participating hospital include early recovery after surgery principles in their perioperative care pathways, formal compliance audits are not routinely undertaken. HFOT has been described as both an alternate and complementary therapy to NIV.[11–13 28] However, it is uncertain whether those with hypoxaemia diagnosed with the Air test 90 currently receive HFOT. As such, HFOT initiation and duration if prescribed by the medical team in line with local practice will be recorded but not protocolised. Incentive spirometers are routinely provided by nursing staff to all patients within 24 hours of major abdominal surgery at the trial site. Physiotherapists will not encourage incentive spirometer use in trial participants. Any other physiotherapy interventions provided following the index surgery and prior to study enrolment will be recorded.

Reduced physiotherapy services on weekends have been cited as a barrier to delivery of physiotherapy-led NIV.[14] PHYSIO+++ treatment protocols will be provided on weekends if within the first 2 days following trial recruitment. Beyond this, protocolised treatments will only continue if the site's weekend physiotherapy service criteria are met. Overnight physiotherapy service may be requested by the daytime ward physiotherapist or overnight treating medical or nursing staff with continuation of protocolised treatments if the participant meets the site's oncall physiotherapy service criteria. Frequency of weekend and overnight physiotherapy sessions will be recorded.

Trial withdrawal

A participant can decline protocol treatments at any time without reason and remain in the trial. Participants are withdrawn from the trial if they withdraw consent to the trial. The number of participants who withdraw and/or are lost to follow-up at each time point will be reported (online supplemental figure 1).

Outcomes

Primary outcomes

Primary outcomes assess the feasibility of trial processes and treatment delivery.

Trial feasibility

1. Accrual—number of eligible patients recruited per week.
2. Adherence to protocol: total NIV time delivered (minutes) from trial recruitment until a trial end point is met.
3. Acceptability of treatments to participants and clinicians as recorded with a customised acceptability questionnaire devised based on the theoretical framework of acceptability[29] (online supplemental figures 2 and 3).

Safety of interventions

1. Number of adverse or serious adverse events per treatment and group, occurring during or within 15 min of a treatment session and attributable to trial treatments. Defined in line with those described in previous trials of similar populations and treatments.[30]

Transient event: A temporary physiological change (vital signs) or patient-reported condition (pain/claustrophobia) which resolves with cessation of treatment. For example, blood pressure or heart rate outside of acceptable limits or a change >20% from resting levels during treatment which resolves with cessation of treatment.

Adverse event: An unintended deterioration in medical condition attributable to trial treatments which does not resolve when treatment has ceased, requiring medical team review and a change in medical management. For example, a drop in blood pressure below the target range which does not resolve on treatment cessation, requires medical review and inotrope support.

Serious adverse event: Any adverse event attributable to trial treatments that results in death, is life-threatening, requires hospitalisation or prolongation of existing hospitalisation or results in persistent or significant disability or incapacity.[31]

Adverse event/s that occur during protocol treatments will be recorded in the medical chart and the principal investigator notified. Usual care and governance processes will be followed including immediate notification to the treating nurse, nurse manager, treating medical team or activation or a medical emergency response team as indicated.

Secondary feasibility and exploratory outcomes

Secondary feasibility outcomes include measures of recruitment process feasibility and the fidelity of treatments. Exploratory outcomes include measures of the response to treatment, composite PPC[26 32] and pneumonia[33] (online supplemental table 4), escalation of care, changes in functional activity status,[34] health-related quality of life,[35] days alive and out of hospital,[36] hospital resource usage and mortality. Secondary feasibility and exploratory outcomes are further detailed in table 1 and online supplemental table 5.

The Melbourne Group Score has been used previously in physiotherapy trials as a composite PPC outcome measure and is reliable, valid and sensitive to change.[26 30 37]

Participant timeline

Table 1 summarises the schedule of enrolment, interventions and assessments.[38]

Sample size

Although this pilot study's primary outcome is to test trial procedures, feasibility and safety, secondary

Table 1 PHYSIO+++ timeline and schedule of events

		Study period			
		Eligibility Enrolment Allocation	Postallocation		
		0	$T_1 - T_7$	T_8	T_9
Time point		**4–72 hours postoperative**	**POD 0–7**	**D/C**	**90 days postoperative**
Enrolment	Eligibility screen	X			
	Informed consent	X			
	Enrolment	X			
	Random allocation	X			
Interventions	ACTIVE CONTROL: Talk, Walk, Breathe		X		
	INTERVENTION: Talk, Walk, Breathe and NIV		X		
Variables	Baseline data: Demographics, medical history, comorbidities[44], ARISCAT[45]	X			
	Intraoperative variables	X			
	Postoperative variables		X		
Measurement and outcomes	Feasibility of recruitment processes	X			
	DASI[34], EQ5D[35], CFS[46]	Preop: CFS EQ5D DASI	EQ5D		DASI+EQ5D
	Participant acceptability survey		X		
	Clinician acceptability survey		X		POD 8 recruit 50
	Change in (1) ROX index, (2) PCF pretreatment/ post-treatment		First 2 days		
	Composite PPC diagnosis (1) Abbott,[32](2) MGS[26]. Pneumonia diagnosis[33] Persistent hypoxaemia		X		
	ICU re/admit, reintubation or continuous NIV/ CPAP			30 days postoperative	
	Safety reporting		X		
	Costs of providing Talk, Walk, Breathe, NIV		X		
	Postoperative (1) ICU LOS, (2) acute hospital LOS			X	
	Acute hospital readmission (1) 30, (2) 90 postoperative days				X
	Days alive and out of hospital (1) 30, (2) 90 postoperative days				X
	Patient reported complications				X
	Mortality (1) hospital, (2) 30, (3) 90 postoperative days. Cause of death			X	X

ARISCAT, Assess Respiratory Risk in Surgical Patients in Catalonia; CFS, Clinical Frailty Score; CPAP, continuous positive airway pressure; DASI, Duke Activity Status Index; D/C, discharge; EQ5D, Euroquol 5D; ICU, intensive care unit; LOS, length of stay; MGS, Melbourne Group Score; NIV, non-invasive ventilation; PCF, peak cough flow; POD, postoperative day; PPC, postoperative pulmonary complication; ROX, respiratory rate oxygenation.

clinical outcomes can assist sample size calculations for future phase 3 trials. Statistical modelling indicates that a pilot study of an intervention expected to half a binary outcome needs a sample size of 50 (reduction in incidence from 20% to 10%, one-sided, 80% power) to provide exploratory effect size estimates to guide planning for a future trial.[39] The target sample of 50 participants is anticipated to be achievable, accounting for anticipated non-recruitment of 20% of eligible patients due to exclusion criteria.

METHODS: ASSIGNMENT OF INTERVENTIONS

Randomisation and allocation

Sequence generation and allocation concealment mechanism

The randomisation schedule will be generated using REDCap (Research Electronic Data Capture)[40 41] by a researcher with no further involvement in the trial. Following participant registration in REDCap by the principal investigator (CH) or associate investigator (NRi), concealed random allocation to one of two treatment groups (1:1).

Blinding

Blinded assessors will be senior cardiorespiratory physiotherapists not involved with the care of trial participants, who will collect data as outlined in table 2 and remain blinded to treatment group allocation. Statistical analysis will be conducted by a biostatistician who is blinded to treatment allocation. Blinding of ward staff may not be possible as participants will remain on the ward during treatment. An effort will be made to blind ward staff by closing bed curtains during treatment, removing NIV

Table 2 Data collection

	Data to be collected	Time collected
Assessor blinded to group allocation	Assess patients for pulmonary outcomes daily	POD 0–7
	Administer questionnaires: Participant self-rates a. EQ5D.[35] Retrospective preop and current status b. DASI.[34] Retrospective preop	POD 7 or prior to D/C home
	Record preoperative comorbidities from the medical record including components of the Charlson comorbidity scale and ARISCAT score	During index admission
	Determine preoperative frailty from existing medical records using the Clinical Frailty Score	
	Extract from medical records: a. Baseline, preop, intraoperative and postoperative variables b. Incidence and reason for ICU re/admission, reintubation or continuous NIV/CPAP post-trial c. HFOT: Time to initiation, maximum flow and FiO_2 and duration d. Hospital and ICU postop LOS, incidence and cause of in-hospital death	
	Phone follow-up for each participant a. DASI and EQ5D b. Patient reported complications after hospital discharge to POD 90 c. Acute hospital readmissions within 30 and 90 postoperative days	Postoperative day 90
Treating therapist	Pretreatment and post-treatment ROX index components (SpO_2, FiO_2, RR) and PCF for the first 2 days following enrolment. PCF procedure: While in a supported upright position, the participant will be asked to take a deep breath in, support their abdominal wound and cough strongly into a mask connected to a peak expiratory flow metre (Mini Wright Standard Peak Flow Metre). The best of three coughs will be recorded and reasons if data was not able to be collected.	From enrolment to POD 7
	Treatments delivered, reasons treatment not delivered, breaks to protocol and adverse events	
	Daily modified Iowa Level of Assistance scale[47]	
	Daily readiness for discharge from physiotherapy using the Post-Operative Physiotherapy Discharge Scoring Tool[24] (online supplemental table 2).	

Data points are listed in online supplemental table 6.
ARISCAT, Assess Respiratory Risk in Surgical Patients in Catalonia; CPAP, continuous positive airway pressure; DASI, Duke Activity Status Index; D/C, discharge; EQ5D, Euroquol 5D; FiO_2, fraction of inspired oxygen; HFOT, High Flow Oxygen Therapy; ICU, Intensive Care Unit; LOS, length of stay; NIV, non-invasive ventilation; PCF, peak cough flow; POD, postoperative day; ROX, respiratory rate oxygenation; RR, respiratory rate; SpO_2, oxyhaemoglobin saturation.

device when not in use and delayed documentation of NIV delivered until a patient discharged from hospital.

METHODS: DATA COLLECTION, MANAGEMENT AND ANALYSIS

Assessments and data collection

Data will be collected directly from the participant and the electronic medical record by assessors and treating physiotherapists using standardised case report forms. These data are then entered into a purpose-built secure database. Table 2 describes data collection methods.

Acceptability questionnaires

The Participant Acceptability questionnaire (online supplemental figure 2) will be administered on paper face to face with the participant by a member of the research team once between postoperative days 5–7 or the day of discharge, whichever occurs first.

The Clinician Acceptability questionnaire (online supplemental figure 3) will be provided to consenting physiotherapists (online supplemental file 3—clinician participant information and consent form), who have delivered protocolised treatment. A link to an electronic survey in REDCap will be sent by email to the physiotherapist within 7 days of delivering the protocol for the first time. Clinicians will not receive subsequent surveys if they deliver the protocol to multiple patients, other than at the conclusion of the trial a single repeat survey will be sent. All treating physiotherapists at the Princess Alexandra Hospital will be randomly assigned a clinician trial number for anonymity and will be identified only with this number. The unique clinician trial number will be created by a staff member who is not otherwise involved in the trial, stored electronically and will not be able to be accessed by the principal investigator. To optimise anonymity, the Clinician Acceptability responses will not be analysed until a month following trial completion.

Statistical methods

Flow through the trial will be presented in a Consolidated Standards of Reporting Trials diagram, including number eligible/ineligible, number approached to participate, number randomised and drop-outs. Collected data will be presented using descriptive statistics in the first instance, summarised as a total and by treatment group. Continuous data will be summarised by mean and SD if normally distributed, and median and IQR if non-normally

distributed. Categorical data will be summarised using frequencies and proportions. Treatment groups will be compared using t-tests, χ^2 tests and their non-parametric equivalents if necessary. The primary outcome of trial feasibility and treatment delivery will be assessed through counts of patient recruitment, adherence to protocol by comparing total NIV time delivered and acceptability questionnaires. Secondary explorative outcomes will be assessed using both repeated measures and time-to-event analyses depending on the outcome. Primary models of interest will be unadjusted and carried out according to the intention-to-treat principle. A second model adjusting for known covariates of interest, including direct ICU admission following surgery, emergency surgery, current smoker and respiratory comorbidities, will also be performed. Depending on data distribution, per-protocol analyses may be conducted to explore if there is an interaction between dosage and outcomes. Values are two sided with <0.05 considered statistically significant.

Data monitoring, auditing and access

As a pilot study, neither a data monitoring committee nor auditing is planned. Random audits may occur by the approving ethics committee for trials conducted at our site. Requests for access to trial data, directed to the principal investigator will be considered by the sponsor.

Trial status

This trial is currently active. First participant was recruited on 20 January 2023. It is anticipated that data analysis will begin in November 2023.

DISCUSSION

Timely therapy is critical for those with postoperative hypoxaemia. Following surgery, if assessment of a patient's oxygen levels is conducted with routine oxygen therapy in place, hypoxaemia may go undetected and result in delayed care.[42] The PHYSIO+++ trial will potentially unmask hidden hypoxaemia by screening patients with the Air Test 90. The validity of a postoperative Air Test to diagnose atelectasis and predict PPC has been demonstrated.[21 22] However, the Air Test has not previously been used by physiotherapists to enrich a study population.

The PHYSIO+++ trial approach to recruitment is unique as we will not exclude patients diagnosed with a PPC at the time of enrolment. This may result in a heterogeneous sample, however, will provide important information to inform future trial design. Prevention of PPCs is paramount, however, total eradication may not be realistic. As such, evidence to guide physiotherapy management of established PPCs is crucial. We will report the severity of PPCs to track progression and potential response to treatment over time. PPC severity has recently been identified as a novel outcome measure for perioperative clinical trials.[43]

PHYSIO+++ is the first randomised trial to assess protocolised physiotherapy treatments for adults with hypoxaemia after major abdominal surgery. This study will assess whether it is feasible to recruit patients and deliver physiotherapy interventions. PHYSIO+++ will provide vital information about the feasibility of trial processes and treatments to direct future adequately powered physiotherapy efficacy trials.

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Contributors CH and IB conceived the study. CH, IB, LD and PK codesigned the study and protocol development. NRe, CH and IB designed the statistical analysis plan. NRi, BMS, RMW and LH assisted with study design. CH prepared the first draft of the protocol manuscript and was responsible for the final manuscript. All authors revised all manuscript drafts, approved the final manuscript and contributed intellectually important content. CH is the guarantor of the paper and takes responsibility for the integrity of the work as a whole, from inception to published article.

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Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

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