The physiotherapy management of patients undergoing abdominal surgery

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ABSTRACT

Abdominal surgery is performed to remove cancerous tissue, to resolve visceral tissue perforations or to remove inflammatory bowel segments, benign growths or vascular aneurysms. Postoperative complications, including pulmonary complications, are common following abdominal surgery and physiotherapy aims to prevent and treat many of these complications. Much of the literature investigating physiotherapy interventions is over a decade old and advances in surgery, including minimally invasive surgery and fast track pathways, require physiotherapists to re-evaluate their practices. This narrative review aims to examine the evidence investigating the effectiveness of physiotherapy interventions and apply this to contemporary surgical practices. Recommendations for practice and research are outlined.

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INTRODUCTION

Abdominal surgery is the most frequently undertaken surgery type in Australia and New Zealand. At least 130,000 operations were performed in 2012-2013 across 246 hospitals in Australia alone and this is increasing by 2-5% per year (AIHW 2013). World-wide, approximately 500 to 1,000 procedures per 100,000 head of population are performed annually in developed countries (Weiser et al 2008).

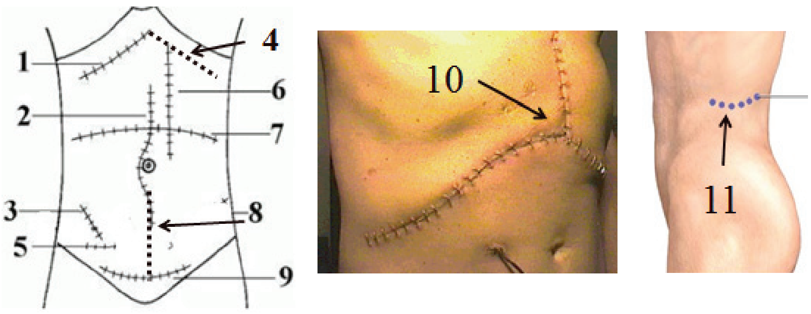
Postoperative complications are common following major abdominal surgery with one third to half of all patients having some type of complication following their operation (Aahlin et al 2015, Hamel et al 2005). Complications, such as postoperative pulmonary complications (PPC), prolonged postoperative ileus and the sequelae of prolonged immobility are potentially preventable with physiotherapy interventions. Physiotherapists have routinely provided care to patients undergoing abdominal surgery since the 1950s (Cash 1955, Innocenti 1996) and research investigating the effectiveness of physiotherapy following abdominal surgery is generally over a decade old (Pasquina et al 2006). Since this time, major advances in surgery, such as minimally invasive surgical techniques and improved perioperative management, have significantly reduced postoperative complications and length of hospital stay (LOS) (Spanjersberg et al 2015). These advances require a re-evaluation of physiotherapy for patients undergoing abdominal surgery.

What is abdominal surgery?

Abdominal surgery can be categorised according to the location and length of the main incision. Upper abdominal surgery (UAS) involves an incision above or extending above the umbilicus and lower abdominal surgery (LAS) involves incisions wholly below the umbilicus (see Table 1 and Figure 1). Surgery may be open (with an incision >5cm), laparoscopic or a combination of both. Historically, laparoscopic surgery was predominantly performed for cholecystectomy and gynaecological procedures only. Recently, major procedures such as bowel, liver, stomach, oesophagus and kidney resections are being performed laparascopically or as laparoscopic hand-assisted surgery (minimally invasive surgery), whereby an additional incision allows a hand to pass into the abdomen for surgical manipulation and tissue removal (see Figure 2). Although, minimally invasive surgery involves longer anaesthetic times (Owen et al 2013) compared with the equivalent open procedure, accelerated recovery, reduced complication rates and shorter LOS have been demonstrated (Spanjersberg et al 2015).

Table 1. Type and location of abdominal surgical procedures

Surgical Category	Upper Abdominal	Lower abdominal
Colorectal	Anterior resection Abdominoperineal resection Hartmanns Hemicolectomy Low anterior resection Laparoscopic (+/-hand) assisted colectomy Partial colectomy Proctocolectomy Reversal of Hartmanns Sigmoid colectomy Small bowel resection Subtotal colectomy Total colectomy	Ultra low anterior resection Recto-sigmoidectomy Ileostomy Appendectomy
Upper Gastrointestinal	Gastrectomy Liver resection Oesophagectomy Open cholecystectomy Open hiatus hernia repair Pancreatic surgery Whipples	
Urology	Adrenalectomy Cystic duct excision Nephrectomy Laparoscopic +/- hand assisted nephrectomy Pyeloplasty Radical cystectomy +/- ileal conduit Radical cystoprostatectomy	Radical prostatectomy Ureterectomy
Other	Explorative laparotomy Splenectomy Complete pelvic exenteration	Inguinal hernia repair Total abdominal hysterectomy



1.	Subcostal (Kocher)	Liver and pancreas operations
2.	Midline laparotomy	Upper and lower intestinal procedures, major bladder
3.	McBurney	Appendix removal
4.	Bilateral subcostal (Chevron)	Oseophageal, liver, pancreatic, and gastric procedures
5.	Lanz	Appendix removal
6.	Paramedian	Upper gastrointestinal surgery
7.	Transverse	Upper intestinal procedures
8.	Lower midline	Lower intestinal procedures and bladder
9.	Pfannenstiel	Major gynaecological and prostate procedures
10.	Mercedes (Chevron + Sternotomy)	Major trauma, combined cardiac and abdominal
11.	Flank/transverse lumbar	Kidney procedures

Figure 1: Incisions used for abdominal surgery and associated procedures (Mercedes image: Said 2008)

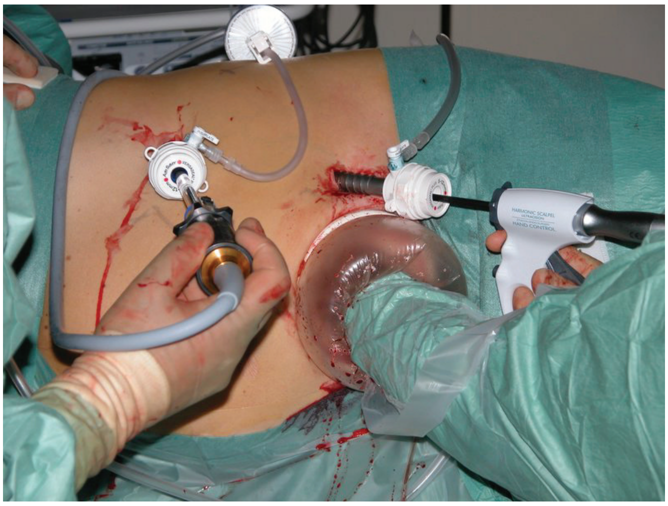


Figure 2: Laparoscopic hand-assisted abdominal surgery (Dols et al 2009)

Significant changes in perioperative care have also been initiated, most notably Enhanced Recovery after Surgery (ERAS) or 'fast track' pathways. Elements include minimal preoperative bowel preparation and fasting, admission on the day of surgery, aggressive early ambulation, strict analgesia protocols, early postoperative introduction of oral fluids and food, and minimal use of drips and drains. These pathways are safe, feasible and reduce complication rates and LOS across all types of abdominal surgery (Adamina et al 2011, Cerantola et al 2013, Coolsen et al 2013, Li et al 2012, Lin et al 2011, Varadhan et al 2010, Wijk et al 2014).

Prevention of postoperative complications relevant to physiotherapy

Postoperative pulmonary complications (PPCs)

What are PPCs and how are they measured?

A PPC is commonly described as "a pulmonary abnormality that produces identifiable disease or dysfunction, that is clinically significant and adversely affects the clinical course" (O'Donohue Jr 1992). This can include respiratory failure, pneumonia, severe atelectasis, pulmonary oedema, pneumothorax, and pleural effusion. A PPC is the most common complication following UAS (PROVHILO group 2014) with a reported incidence of 13-53% (Browning et al 2007, Haines et al 2013, Mackay et al 2005, Parry et al 2014, Scholes et al 2009, Silva et al 2013). This is higher than other major surgical procedures, such as open lung resection, cardiac surgery via sternotomy, and orthopaedic surgery (Arozullah 2001, Pasquina and Walder 2003, Reeve et al 2010), whereas the PPC rate following open LAS is as little as 1% (Arozullah 2001, Smith et al 2009a).

The wide range in reported PPC rates following UAS may be explained by the surgical procedures, patient populations studied, and the PPC diagnostic tool or criteria utilised. Diagnosis of a PPC differs greatly between studies. Variations include the individual signs and symptoms required for diagnosis (e.g. some tools incorporate auscultation changes where others do not), how each criterion is measured (e.g. the different grading scales used for radiographic atelectasis or consolidation) and the threshold number of positive criteria equating to a PPC (Agostini et al 2011, Wynne 2004). These inconsistencies make comparison of PPC rates and interpretation of research findings into clinical practice problematic. Although there is no consensus on the ideal tool for PPC diagnosis, recent physiotherapy-led studies have used the same multi-factorial scoring tool, the Melbourne Group Score (Table 2) in both UAS (Browning et al

Table 2: Melbourne Group Score PPC Diagnostic Tool

Diagnosis confirmed when 4 or more of the following are present:
CLINICAL FACTORS
• New abnormal breath sounds on auscultation different to preoperative assessment
• Production of yellow or green sputum different to preoperative assessment
• Pulse oximetry oxygen saturation (SpO_2) <90% on room air on more than one consecutive postoperative day
• Raised maximum oral temperature >38°C on more than one consecutive postoperative day
DIAGNOSTIC FACTORS
• Chest radiograph report of collapse/consolidation.
• An unexplained WCC greater than 11 x 10^9/L
• Presence of infection on sputum culture report
OTHER
• Physician's diagnosis of pneumonia, respiratory tract infection, undefined respiratory problem.
• Prescription of an antibiotic for a respiratory infection

Notes: C, centigrade; L, litre; SpO_2, Peripheral oxygen saturation; WCC, white cell count.

2007, Haines et al 2013, Parry et al 2014, Scholes et al 2009) and thoracic surgery (Agostini et al 2013, Reeve et al 2010). Reliable clinometric properties for the Melbourne Group Score (MGS) are beginning to be demonstrated when compared to other PPC diagnostic tools (Agostini et al 2011). Studies using the MGS have reported PPC rates of 13-18% in all patients undergoing major UAS (Browning et al 2007, Scholes et al 2009), and specifically 39-42% in high-risk UAS patients (Haines et al 2013, Parry et al 2014).

Key Point:
For research, audit and clinical purposes, the use of the Melbourne Group Score tool is recommended to diagnose a PPC amenable to physiotherapy.

What are the consequences and costs of a PPC?
Postoperative pulmonary complications significantly increase morbidity, mortality, hospital utilisation, cost, and length of hospital stay (Dimick et al 2004, Knechtle et al 2014, Lång et al 2001, Rotta et al 2013, Thompson et al 2006). The greatest proportion of hospital costs are associated with intensive care utilisation and hospital LOS (Knechtle et al 2014). Australian prospective observational studies measuring PPC rates using the MGS found that PPCs increased hospital LOS by 3-13 days (Denehy et al 2001, Scholes et al 2009). To date, reported costs associated with PPCs have been derived retrospectively from hospital clinical coding databases that often underreport rates of complications and costs (Koch et al 2012). The true costs of PPCs are important to establish so that the cost-effectiveness of prophylactic interventions, including physiotherapy, can be calculated. It may not be cost effective to provide physiotherapy to *all* patients undergoing abdominal surgery. Where the likelihood of developing a PPC is known to be low, e.g. one PPC in every 100 patients, providing prophylactic physiotherapy to all 100 patients may cost more than the costs saved through preventing the one PPC. However, if PPCs are shown to be high cost, the benefit of preventing one PPC in 100 patients may outweigh the cost of providing a relatively low-cost intervention such as physiotherapy to all 100 patients. Until we have contemporary high quality physiotherapy evidence and cost-benefit analyses, physiotherapists may be best to target interventions to those patients who are at high-risk of postoperative complications. It is therefore important that physiotherapists are able to determine which patients are most at risk of developing a PPC.

Key Point:
Cost-benefit analyses of physiotherapy interventions to reduce PPCs, improve recovery and reduce LOS are needed to inform resource allocation.

How can we predict who is at risk of developing a PPC?
The ability to predict the development of a PPC has been widely investigated. An often cited large prospective cohort study (n=160,805) (Arozullah 2001) investigated *all* patients undergoing non-cardiac surgery and found that those undergoing UAS were almost three times more likely to develop pneumonia (OR 2.68, 95%CI 2.38-3.03) compared to LAS and orthopaedic surgery where the pneumonia rate was less than 1%. A recent retrospective study found that PPCs were 15 times more likely following UAS when compared to LAS (Smith et al 2009a).

The incidence of PPCs after traditional laparoscopic surgery is also negligible (<1%) (Antoniou et al 2014). However, pneumonia rates of 2-5% have recently been reported following minimally invasive bowel resections and, whilst this is half the rate of the equivalent open procedure, PPC incidence has been shown to increase by 13% with each additional 60 minutes of surgery time (Owen et al 2013). The risk of PPCs following other types of minimally invasive UAS is not well reported. Until more data and cost-benefit analyses of physiotherapy interventions are published, it is uncertain if these PPC rates are high enough to justify providing routine prophylactic physiotherapy to these lower-risk patients.

To assist in directing physiotherapy resources to the highest need patients, PPC risk prediction tools should be utilised. Most PPC risk prediction tools following UAS have been developed by medical researchers (Barnett and Moonesinghe 2011) and have limited clinical utility for physiotherapists. To address this a physiotherapist led prospective study (Scholes et al 2009) investigated predictors for PPCs (with MGS diagnosis) to enable the development of a multifactorial scoring tool to dichotomise patients having UAS into high or low risk groups. Independent predictors of PPCs were: anaesthesia longer than three hours, upper gastrointestinal surgery, current smoking history, respiratory disease and estimated VO^{2max}. High-risk patients were 8.5 times more likely to develop a PPC than those assessed as low-risk. Other physiotherapy studies have found additional independent risk factors for a PPC. A nasogastric tube (Parry et al 2013) for more than one day was associated with higher PPC incidence (OR 9.1, 95%CI 2.0 to 42) and delayed time to ambulate more than 10 metres (Haines et al 2013) was three times more likely to be related to the presence of a PPC (OR 3, 95%CI 1.2 to 8).These results should be interpreted with caution, as it is possible that the presence of a PPC delayed mobilisation, rather than vice versa. The use of available PPC risk prediction models to target provision of physiotherapy services to higher-risk patients may be a prudent use of finite physiotherapy resources.

Key Points:
1. Patients following LAS and standard laparoscopic surgery do not require routine postoperative physiotherapy to prevent PPC.
2. All patients undergoing UAS should be screened for risk of developing a PPC using a risk identification tool and those patients determined to be high-risk are targeted with PPC prophylaxis.
3. A PPC risk prediction tool is needed for advanced laparoscopic and minimally invasive UAS.

Complications associated with reduced or delayed mobility
Venous thromboembolism
The absolute risk of venous thromboembolic events (VTE) after major abdominal surgery without preventative measures is approximately 15 – 40% (Cayley 2007). Given the serious

consequences of pulmonary emboli (PE), several guidelines for prevention and management have been published by the American College of Chest Physicians (Holbrook et al 2012), Scottish Intercollegiate Guidelines Network (SIGN 2010) and the National Institute for Health and Clinical Excellence (National Institute for Health and Clinical Excellence (NICE) 2010). These guidelines recommend that all major surgical patients have VTE prophylaxis, including anti-coagulation and early mobilisation. If a deep vein thrombosis (DVT) is diagnosed and anti-coagulation has been commenced, early mobilisation is not associated with increased risk of PE, new DVT or death (Aissaoui et al 2009, Anderson et al 2009), thus physiotherapists should recommence active ambulation following medical clearance.

Postoperative paralytic ileus

Gut immotility immediately postoperatively is an expected consequence of abdominal surgery (Vather et al 2013). There is a widespread belief that early ambulation assists in the resolution of gut immotility and prevention of paralytic ileus, yet there is no conclusive evidence to support this hypothesis (Story and Chamberlain 2009). Indeed, there is stronger evidence for the routine use of chewing gum, which stimulates the neuro-hormonal response to eating and enhances the resolution of a normal gut peristalsis, to prevent paralytic ileus and reduce LOS (Li et al 2013), than there is for early ambulation.

Musculoskeletal and cardiovascular effects

Whilst early ambulation is recommended following major abdominal surgery, surgical drains/devices and the postoperative sequelae of hypotension, nausea, pain, and fatigue mean that achieving early ambulation as recommended is frequently not achieved (Haines 2013, Boulind 2012). Although the deleterious musculoskeletal and cardiovascular effects associated with prolonged bedrest are well documented (Pavy-Le Traon et al 2007), there is little evidence to support the use of early ambulation in the prevention of PPCs. A recent randomised controlled trial (RCT) found no increase in PPC incidence following three days enforced bed rest; rather this group had prolonged LOS and required more physical rehabilitation to assist recovery (Silva 2014).

Physiotherapy management for patients undergoing abdominal surgery

Physiotherapy aims to address well-known pathophysiological effects of abdominal surgery on the respiratory system including atelectasis (Duggan and Kavanagh 2005, Hedenstierna and Edmark 2010, Tusman et al 2012), reduced muco-ciliary clearance (Bilgi et al 2011, Gamsu et al 1976, Konrad et al 1993), diaphragm dysfunction (Blaney and Sawyer 1997, Ford et al 1983, Kim et al 2010), reduced lung volumes (Cheifetz et al 2010, Fagevik Olsén et al 2009, Stock et al 1985) and reduced respiratory muscle and cough strength (Barbalho-Moulim et al 2011, Bellinetti and Thomson 2006, Kulkarni et al 2010). It is hypothesised that combinations of these factors can lead to bacterial proliferation in the airways and/or severe atelectasis (Smith and Ellis 2000), increasing the risk of infection and PPCs.

It is a logical assumption that strategies to ameliorate the deleterious physiological effects of abdominal surgery will result in reducing the risk of PPC development. This has been the underlying premise of the delivery of 'chest physiotherapy' to patients following major surgery for several decades. Physiotherapy may consist of preoperative education and training and/or postoperative respiratory and physical rehabilitation. More recently, there has been an increasing focus on preoperative exercise training (prehabilitation). Here we present the best available evidence to guide practice decisions.

Preoperative physiotherapy interventions

Preoperative education

Preoperative physiotherapy education is the delivery of targeted preparatory information to the patient regarding the expected postoperative participation in an early ambulation programme and necessity to perform deep breathing and coughing (DB&C) exercises. Patients are educated on the role these exercises have on the reduction of serious complications such as PPC and VTEs. Sessions consist of explaining the effect of anaesthesia and surgery on the lungs, teaching and training of DB&C exercises, education on the early ambulation programme and provision of any adjunctive devices as necessary.

Evidence from six clinical trials (Bourn et al 1991, Castillo and Haas 1985, Condie et al 1993, Denehy 2001, Fagevik Olsén et al 1997, Samnani et al 2014) suggests that a single preoperative physiotherapy session significantly reduces PPC rates. In the largest RCT (n=368, PEDro 5/10) the intervention group received a single preoperative physiotherapy education and training session and a single postoperative review of taught breathing exercises (Fagevik Olsén et al 1997). The control group received no pre or postoperative physiotherapy. The incidence of PPC was significantly lower in the treatment group (6% vs 27 %, $p<0.001$).Two other RCTs of 330 low-risk open abdominal surgery (Condie et al 1993) and 102 open UAS patients (Denehy 2001) concluded that the provision of additional postoperative physiotherapy of coached DB&C exercises conferred no extra benefit over and above a single session of preoperative education and DB&C training alone. A recent RCT (Samnani et al 2014) of 232 abdominal surgery patients again demonstrated a significant reduction in PPCs from 30% to 7% (ARR 22%, 95%CI 13%-32%) when preoperative education focused on the importance of postoperative early ambulation compared to no education at all. Both groups were provided with similar postoperative care. These studies demonstrate the effectiveness of preoperative education and DB&C training, independent of postoperative physiotherapy, in reducing the incidence of PPCs.

The reported reduction in PPCs with preoperative physiotherapy education is significant; however, the results need to be interpreted with caution. All trials had methodological limitations and sources of bias. This brings the reported effect on PPC rates into question. Further, most trials were conducted 10-15 years ago and there have been significant changes in surgical and perioperative care in this time. Preoperative education and training have previously been provided the day before surgery upon admission for surgery, however this no longer reflects current practice, whereby patients attend preoperative assessment clinics one to six weeks before their operation (Gupta and Gupta 2010). It is unknown whether preoperative physiotherapy education provided at these longer time intervals might reproduce the previously reported effect on PPC prophylaxis.

Surveys of physiotherapy services to UAS patients in Australia have shown a stark reduction in hospitals providing preoperative physiotherapy education over the past 15 years (Browning 2007, Scholes et al 2006). The reasons for this disinvestment of services are unknown. There are no cost-benefit analysis studies investigating physiotherapy to reduce respiratory complications, so conclusive evidence to inform the allocation of physiotherapy services to preoperative education and training is lacking. The potential to significantly reduce the incidence of a high-impact complication, such as a PPC, with a low-cost and easily provided intervention of a single preoperative physiotherapy session is appealing. It may not be *how much* physiotherapy that is important, but rather, *when* that physiotherapy is provided. The current weight of evidence appears to support the provision of a single preoperative physiotherapy education and DB&C training to all patients having abdominal surgery (Bourn et al 1991, Condie et al 1993, Denehy 2001, Fagevik Olsén et al 1997, Samnani et al 2014). Given the limitations of this research and the low incidence of PPCs following laparoscopic and LAS surgery, the authors recommend the provision of preoperative physiotherapy for all open UAS patients only. Cost benefit studies are required to analyse the fiscal benefits of providing preoperative physiotherapy to lower risk surgical patients as well.

Key Points:

1. A single face to face session of preoperative education and DB&C training should be administered to all patients undergoing open upper abdominal surgery.
2. It is currently unknown if other forms of this education and training, eg video or booklet, are effective.

Prehabilitation

Prehabilitation refers to the use of exercise-based interventions aimed at optimising preoperative function to improve postoperative outcomes or to increase surgical options in those patients who have borderline fitness for surgery. Evidence of the effectiveness of prehabilitation is relatively new, yet systematic reviews and meta-analyses have already been undertaken (Lemanu et al 2013, Olsén and Anzén 2012, Singh et al 2013, Valkenet et al 2011), although only two focused solely on major abdominal surgery (Pouwels et al 2014, Pouwels et al 2015).

Valkenet et al (2011) and Santa Mina (2014) conducted meta-analyses on the effects of preoperative interventions including inspiratory muscle training (IMT) and/or exercise training in patients undergoing major cavity and orthopaedic surgery. Mans et al (2015) investigated IMT prior to all types of open major cavity surgery, including UAS. Meta-analyses of the data demonstrated significant reduction in the risk of PPCs (Mans et al 2015, Valkenet et al 2011) and reduced postoperative length of stay (Santa Mina et al 2014, Valkenet et al 2011). Other systematic reviews report improvements in aerobic and functional capacity (Lemanu et al 2013, Olsén and Anzén 2012, Singh et al 2013). These reviews are limited by the lack of meta-analysis due to the small number of studies included and the heterogeneity of the surgical groups, which included combinations of orthopaedic, UAS, cardiac and thoracic surgery.

To our knowledge, there are only two systematic reviews specifically relating to prehabilitation in abdominal surgery (Pouwels et al 2014, Pouwels et al 2015). These two reviews detailed six RCTs in both laparoscopic and open abdominal surgery (Pouwels et al 2014) and five studies in abdominal aortic aneurysm repair specifically (Pouwels et al 2015). Studies investigated strength and/or aerobic training, breathing exercises, education and IMT or combinations of these. The heterogeneity of the investigations precluded meta-analyses as studies utilised a variety of frequencies, intensities, durations, modes, locations and outcome measures. Both reviews (Pouwels et al 2014, Pouwels et al 2015) determined that preoperative exercise therapy is associated with improved physical fitness in patients prior to major abdominal surgery, but, due to heterogeneity and small sample sizes, whether this results in fewer complications or faster recovery remains unclear. Although the relationship between poor preoperative fitness and postoperative outcomes has been clearly demonstrated (Smith et al 2009b), the effect of improving fitness (via prehabilitation) and improved postoperative outcomes is yet to be demonstrated. Better quality, targeted research into preoperative physical fitness optimisation, particularly in high-risk patients, is warranted.

Key Point:

Given the small number of studies, the heterogeneity of interventions and costs involved in providing such services, the routine provision of prehabilitation in all patients undergoing abdominal surgery cannot be recommended. However, it may be worthwhile in high-risk UAS patients, given the assumed cost of complications. This remains to be confirmed with cost-benefit studies.

Postoperative physiotherapy interventions

Postoperative ambulation

Early mobilisation forms a routine part of postoperative care and physiotherapists are heavily involved in the initiation of mobilisation following UAS, with up to 91% reporting they always include mobilisation in their postoperative treatment (Browning 2007). Patients perform little mobilisation outside of physiotherapy treatment in the early postoperative period (Browning et al 2007) with one study demonstrating only 48% of patients mobilised more than 10m on the first postoperative day (Haines et al 2013). To address this, aggressive early ambulation protocols have become an essential component of ERAS guidelines whereby patients sit up out of bed for six to eight hours and ambulate at least 60m up to five times on the day after surgery (Delaney et al 2001). However only 40% of patients are able to achieve this (Boulind et al 2012). Studies investigating adherence to ERAS protocols found the early mobilisation component was the least adhered to (Boulind et al 2012, Gustafsson et al 2011). Barriers to achieving early ambulation include hypotension, pain and nausea (Haines et al 2013).

Research into the efficacy of physiotherapy to improve outcomes following abdominal surgery has almost always involved ambulation as part of an intervention package (e.g. preoperative education, DB&C exercises, early ambulation, adjunctive devices). It is difficult to determine which component of the intervention is responsible for any improvements in outcomes.

Only two studies have attempted to specifically isolate the effect of DB&C from standardised early ambulation. Mackay et al (2005) compared PPC rates in 56 patients randomised to an ambulation only group or a group provided with additional supervised DB&C exercises; of note the protocol for both groups was intensive, with three ambulation sessions on the first and second postoperative day and continuing twice daily for the next two days. The overall PPC rate was 14% with no significant difference between groups. A similar study replicated this protocol with a more realistic ambulation protocol. Silva et al (2013) randomised 86 high-risk UAS patients into three groups: mobilisation alone, mobilisation plus DB&C, and delayed mobilisation (commenced on the third postoperative day) plus DB&C. Participants were ambulated once daily to a BORG intensity of 6/10. There were no significant differences in PPC rate between groups even in the group that rested in bed for three days; although this group were no more likely to get a PPC, they had increased requirements for physiotherapy to assist in their physical recovery and significantly longer LOS (MD 4.4, 95%CI 0.3 to 8.8). Both of these studies suggest that the addition of DB&C to early ambulation does not reduce the incidence of PPC. However, it is important to note that these studies were not powered to measure small to moderate differences in PPC rates (less than 20% between groups). It is possible that coached DB&C exercises could provide a small, yet clinically worthwhile effect. Much larger clinical trials would need to be performed to test this.

Key Points:

1. Because of the undesirable sequelae associated with prolonged bedrest, ambulation should be commenced as early as safely possible for all patients undergoing all types of abdominal surgery.
2. There is little evidence to support the use of early ambulation in the prevention of PPCs.
3. The ideal amount, duration, and frequency, of ambulation required to improve postoperative recovery is untested.

Postoperative breathing exercises.

Coached DB&C exercises are traditionally provided to patients following UAS aiming to prevent PPCs. Incentive spirometers (IS) (do Nascimento Junior et al 2014), PEP devices (Orman and Westerdahl 2010, Zhang et al 2015), and non-invasive ventilation (NIV) (Ferreyra et al 2008) are also utilised, but less frequently. These modalities are often delivered by physiotherapists (Haines et al 2013, Makhabah et al 2013), although in some countries these may be provided by other health professionals (Cassidy et al 2013, Zhang et al 2015). Despite widespread and ubiquitous provision of prophylactic respiratory physiotherapy following abdominal surgery, its efficacy and worth in preventing PPCs is unclear.

Two systematic reviews have investigated interventions to prevent PPCs following abdominal surgery (Lawrence et al 2006, Pasquina et al 2006). Despite being conducted in the same year, the conclusions were contradictory. Lawrence et al (2006) investigated all non-pharmaceutical interventions to prevent respiratory complications including a wide range of interventions (such as nasogastric decompression, postoperative analgesia) in open, laparoscopic, LAS and UAS. Findings suggested there is good evidence for any type of lung expansion manoeuvres compared with no treatment at all but that studies were confounded by the use of multimodal interventions, inconsistent definitions of PPC and poor methodologies. Pasquina et al (2006), in a robust and detailed systematic review, focused solely on physiotherapy interventions and meta-analysed 35 studies conducted in both LAS and UAS. Less than half of all trials found that DB&C exercises were more effective than a no-treatment control or alternative technique. They concluded that the routine use of respiratory physiotherapy after open abdominal surgery is not justified.

Since the 2006 publication of these systematic reviews (Lawrence et al 2006, Pasquina et al 2006), seven additional RCTs have been published (Baltieri et al 2014, Barbalho-Moulim et al 2011, Dronkers 2008, Kulkarni et al 2010, Samnani et al 2014, Silva et al 2013, Zhang et al 2015). The findings of these further studies are summarised in Table 3 and the results and context of the findings are discussed elsewhere in this paper where appropriate. The methodological quality of each of these trials has been assessed using the PEDro scale and absolute risk reduction (including confidence intervals) and number needed to treat have been calculated from the dichotomous PPC data supplied in the studies where possible.

One further systematic review assessed specifically the effect of breathing exercises on physiological aspects of pulmonary function following abdominal surgery such as respiratory muscle strength and diaphragm mobility (Grams et al 2012). This study and others (Grams et al 2012, Lunardi et al 2013, Lunardi et al 2015) have demonstrated that DB&C improve respiratory function following UAS, although it remains unclear whether these physiological improvements translate to clinically meaningful reductions in LOS or incidence of PPCs.

In the face of contradictory evidence for the use of DB&C exercises, an international panel of experts have attempted to provide a consensus statement on physiotherapy management for patients following UAS (Hanekom et al 2012). Using the Grades of Recommendation, Assessment, Development and Evaluation (GRADE) approach (Guyatt et al 2008), the panel considered the potential benefits of coached DB&C exercises outweighs the potential costs and harms of the intervention. Until this is confirmed with further high-quality evidence and cost-benefit analysis this recommendation remains supported by a weak level of evidence.

Regarding laparoscopic and LAS, although respiratory physiotherapy demonstrates physiological improvements in pulmonary function (Forti et al 2009, Gastaldi et al 2008, Krishna et al 2013), the PPC rate is very low (Arozullah et al 2000, Condie et al 1993) and postoperative respiratory physiotherapy for this population has not been shown to alter clinical outcomes such as incidence of PPC and LOS . However, with the increasing use of advanced technology, more complex surgeries are now being performed laparoscopically. Due to their complexity, the average time of these type of laparoscopic operations are usually greater than three hours (Fagevik Olsen M 1999, Kuo et al 2013, Park et al 2011). In these studies, the

PPC incidence between open and laparoscopic surgery is similar, suggesting that there may be an increased PPC risk in prolonged laparoscopic surgery (Kuo et al 2013, Park et al 2011). This needs to be confirmed with prospective observational studies to enable risk prediction models to be developed, which will in turn assist physiotherapists and hospitals to determine which patients require targeted PPC prophylaxis following these newer types of procedures. To date, no study has investigated the effectiveness of any type of respiratory therapy to *treat* a PPC following diagnosis and this requires urgent investigation.

Key Points:

1. DB&C exercises should not be provided routinely following LAS, standard laparoscopic surgery or for patients screened as being at low-risk of a PPC following UAS.
2. For high-risk UAS patients, on balance of the available evidence, the provision of coached DB&C exercises may be unnecessary as long as patients are provided with an early ambulation programme of assisted walking at least once a day. It is suggested this assisted walking targets a BORG score > 6/10.

Respiratory adjuncts

Systematic reviews and meta-analyses (do Nascimento Junior et al 2014, Overend et al 2001) have investigated the use of incentive spirometry (IS) for patients following abdominal surgery. In the most recent meta-analysis, do Nascimento Junior et al (2014) investigated 12 studies with a total of 1834 participants undergoing UAS including laparoscopic surgery. Trials compared IS to either no respiratory treatment; DB&C; or to other types of chest physiotherapy. There were no statistically significant differences between any groups in the risk of developing a pulmonary condition. There are limitations with this literature due to mixed patient populations in some studies (UAS, LAS, laparoscopic) and due to varying risk profiles of patients. These limitations and the generally low quality of the evidence regarding the lack of effectiveness of IS in preventing PPCs following UAS highlight the need to conduct well-designed trials in this field. Recently there has been a renewed interest in investigating IS in high-risk populations. For example, a pre-post cohort study in patients undergoing high-risk UAS has shown promising results (Westwood et al 2007) and these results now need to be tested in a RCT.

Only one systematic review has investigated the use of PEP devices (including bubble PEP) in patients undergoing open abdominal or thoracic surgery (Orman and Westerdahl 2010). The review found weak evidence that PEP confers any benefit over standard respiratory physiotherapy but due to the age and limited quality of the included studies (PEDro 4 – 6), firm conclusions are unable to be drawn. A recent well-designed RCT (PEDro 8/10) compared routine medical management and early mobilisation with the use of modified oscillating PEP in 203 patients following UAS and thoracic surgery (see Table 3 for details) (Zhang et al 2015). The study found a significant reduction in days of fever and LOS in the PEP group (MD–2.6, 95% CI -4.8 to –0.4). The use of postoperative (oscillatory) PEP now requires further corroboration with studies in other countries and other surgical contexts, utilising outcome measures that include PPC incidence.

Two meta-analyses have compared prophylactic continuous positive airways pressure (CPAP), to prevent postoperative morbidity and mortality in patients following major abdominal surgery, with standard care (including physiotherapy) (Ferreyra et al 2008, Ireland et al 2014). Whilst no differences were found in the effects of CPAP on mortality and hypoxaemia, both studies showed significant reductions in atelectasis, pneumonia and re-intubation rate with CPAP. Caution is required in extrapolating these results as the included studies had substantial heterogeneity, small sample sizes and a number were old with poor methodological reporting. There is evidence to suggest that CPAP and NIV are both effective in improving outcomes in patients who have developed postoperative respiratory failure although this is based on a small number of studies (Antonelli et al 2000, Chiumello et al 2011, Kindgen-Milles et al 2005).

Other adjuncts

The use of an abdominal binder, a firm removable elastic girdle placed around the abdomen, is popular in some countries following abdominal surgery in attempting to prevent wound dehiscence and improve postoperative pain and respiratory function (Bouvier et al 2014). Its use has shown improvements in postoperative walking distance following major UAS (Cheifetz et al 2010), but only weak effects on reducing pain (Rothman et al 2014) and no effect on pulmonary function or seroma formation (Fagevik Olsén et al 2009, Larson et al 2009, Rothman et al 2014) or LOS (Larson et al 2009). There is some evidence to suggest that abdominal binders improve psychological distress in the early postoperative period (Rothman et al 2014). Its use has yet to be related to PPC rates but evidence suggests that binders can be worn without compromising pulmonary function (Rothman et al 2014).

Key Points:

1. Incentive spirometry should not be routinely provided following abdominal surgery.
2. The use of oscillatory PEP may assist in preventing PPCs.
3. Postoperative prophylactic CPAP/NIV is efficacious in the prevention of PPCs, although evidence is insufficient on the potential for harm and the cost implications of providing CPAP/NIV prophylactically to all patients following UAS need to be considered.

Post-discharge rehabilitation

Health-related quality of life (HRQoL) has become an important end-point in the abdominal surgical literature. Delayed recovery and persistent disability following UAS has been demonstrated up to six months postoperatively (Lawrence et al 2004), with complications in the immediate postoperative period being independent predictors of poorer recovery and poor HRQoL (Davies et al 2013, Lawrence et al 2004). It is unknown if delays in functional recovery (or functional decline) following UAS are related to increased health utilisation costs, morbidity and mortality or if postoperative rehabilitation programmes would hasten recovery and reduce disability. To our knowledge, there are currently no studies investigating the impact of postoperative rehabilitation specifically for patients having undergone UAS. There is, however, a plethora of emerging literature demonstrating positive health benefits (including disease-free survival) at all stages of treatment in cancer survivors. Given that patients with cancer frequently present for abdominal surgery, and the known delayed recovery from UAS in some patients, the value of post-discharge rehabilitation for patients following UAS warrants further exploration.

Key Point:
In the absence of any evidence regarding postoperative rehabilitation programmes we are unable to make any recommendations regarding post-discharge physiotherapy.

CONCLUSION

The research regarding physiotherapy in the perioperative period for patients undergoing abdominal surgery is limited and equivocal. Physiotherapy services rely not only on the balance of evidence but on the balance of resources to provide these services. It is feasible that the potential high cost of PPCs following abdominal surgery justifies the provision of low-cost interventions such as physiotherapy. Until this has been confirmed with good quality research and cost analysis studies, physiotherapists should provide a service based on the best available evidence. This study has attempted to summarise such evidence, highlight the areas required for further research and make balanced recommendations for practice on the basis of these factors.

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Table 3: PPC incidence rates in studies investigating physiotherapy interventions in major upper abdominal surgery published since systematic reviews of Lawrence (2006) and Pasquina (2006)

Author/year /country	Study type	Abdominal surgery types and risk profiles	Sample size	PEDro score	Interventions	PPC diagnostic criteria	PPC rate, % (95% CI)	ARR % (95% CI) NNT	Conclusion
Randomised controlled trials									
(Zhang et al 2015) China	Randomised controlled trial Multi-centre	Thoracic and UAS (open and laparoscopic) Mixed risk profiles	203	8/10	C: Standard ward care. No pre or postop physiotherapy Rx: Postop flutter 5-10 reps, 3 times daily, POD1-5	Any of the following: • Incidence of fever • Abnormal CXR • WCC • Antibiotic therapy	Fever incidence C: 39% (30-49%) Rx: 22% (15-31%)	17% (4-29%) NNT= 6 (3 to 22)	Flutter use following major thoracic and UAS halves fever incidence and reduces LOS, but not abnormalities in CXR or WCC, nor does it reduce antibiotic usage.
(Baltieri et al 2014) Brazil	Randomised controlled trial Single centre	Gastric bypass via open laparotomy, BMI > 40 High-risk	40	6/10	C: Physio DB&C, incentive spirometry, early mobilisation Rx A: BiPAP 1 hr prior to surgery Rx B: BiPAP 1 hr after surgery Rx C: PEEP 10cmH20 intraoperatively	Atelectasis on CXR	C: 20% (6-51%) Rx A: 10% (2-40%) Rx B: 0% Rx C: 10% (2-40%)	Not significant	Inadequate sample size to determine a conclusion.
(Samnani et al 2014) Pakistan	Pseudo randomised controlled trial Single centre	Low-risk, non-smokers, ASA 1 and 2, elective and emergency, open upper and lower abdominal surgery	224	5/10	C: Basic preop education Rx: Additional preop education on early ambulation Postop all received early ambulation > 10 minutes duration and those with prolonged operation time received "chest physio" and incentive spirometers.	Modified Melbourne group scale with 3 or more of the factors	C: 30% (22-39%) Rx: 7% (4-13%)	22% (13-32%) NNT= 4 (3 to 8)	Preop counselling on expected postoperative early ambulation leads to earlier mobilisation and significantly reduces PPCs.
(Silva et al 2013) Australia	Cluster randomised controlled trial Single centre	High-risk elective UAS Excluded: AAA, oesophagectomy	86	7/10	C: Assisted ambulation with Physio once daily at least RPE 6/10. RxA: As control + coached DB&C (4 x 5 reps with 3 sec inspiratory holds) RxB: Rest in bed for POD1 and 2 + coached DB&C as above. Assisted ambulation on POD3.	3 or more in the same day: • Auscultation changes • Temp >38 • CXR changes • Sputum changes	C: 21% (10-40%) RxA: 25% (13-43%) RxB: 10% (3-26%)	No significant difference in PPC rates	Inadequate sample size to determine a difference in PPCs.

(Barbalho-Moulim et al 2011) Brazil	Randomised controlled trial Single centre	Elective open bariatric surgery in females of short LOS (<3days)	32	7/10	C: Preop education on DB&C and early mobilisation. Postop daily physio of DB&C, incentive spirometry, early mobilisation Rx: Additional preop IMT, 15min, once daily, 6 days/wk, 2-4 wks prior to surgery. 30% MIP increasing twice weekly.	One or more of: • Pneumonia • CXR atelectasis with dyspnoea • Acute respiratory failure	0%	n/a	Inadequate sample size to determine a difference in PPCs in this low risk, short LOS population.
(Kulkarni et al 2010) England	Randomised controlled trial Single centre	Major elective UAS	80	5/10	C: No treatment RxA: DB exercises RxB: Incentive spirometry RxC: IMT, 20-30% MIP All exercises performed 15mins, twice daily, 7 days a week for 2 weeks prior to surgery	Chest infections requiring antibiotic treatment	C: 10% (3-30%) RxA: 5% (1-24%) RxB: 0% RxC: 0%	ISQ	Inadequate sample size to determine a difference in PPCs.
(Dronkers 2008) Netherlands	Randomised controlled trial Single centre	High-risk AAA repairs	20	7/10	C: Preop DB&C training, incentive spirometry. Postop physio of coached DB&C, incentive spirometry and early mobilisation Rx: IMT daily for 15min, 6 days a week. 2 weeks prior to surgery. 20% of MIP and increasing resistance to maintain RPE >5/10	Atelectasis on CXR	C: 80% (49-94%) Rx: 30% (11-60%)	50% (6-74%) NNT=2 (1-15)	Preop IMT reduces postoperative atelectasis following AAA repairs
Pre-post cohort studies									
(Lunardi et al 2011) Brazil	Pre-post cohort Single centre	Elective Oesophagectomy High-risk	70	n/a	C: No physiotherapy Rx: 20 minutes daily DB&C, early mobilisation	Any of the following: • Atelectasis on CXR • Pneumonia • Pleural effusion	C: 37% (22-54%) Rx: 15% (7-29%)	21% (1-41%) NNT = 5 (2 to 80)	Chest physio is likely to reduce PPCs following oesophagectomy
(Lunardi et al 2008) Brazil	Pre-post cohort Single centre	Oesophagectomy High risk, elective	40	n/a	RxA: Chest Physio only in ICU RxB: Chest Physio in ICU and through to hospital discharge	Any of the following: • Atelectasis on CXR • Pneumonia • Pleural effusion	RxA: 30% (14-52%) RxB: 10% (3-30%)	Not significant	Inadequate sample size to draw conclusions. Trend towards additional Physiotherapy beyond ICU reducing PPCs.

Table 3: PPC incidence rates in studies investigating physiotherapy interventions in major upper abdominal surgery published since systematic reviews of Lawrence (2006) and Pasquina (2006) *(continued)*

Author/year /country	Study type	Abdominal surgery types and risk profiles	Sample size	PEDro score	Interventions	PPC diagnostic criteria	PPC rate, % (95% CI)	ARR % (95% CI) NNT	Conclusion
(Nakamura et al 2008) Japan	Pre-post cohort Single centre	Elective oesophagectomy High-risk	184	n/a	C: Open surgery, no physiotherapy 1991-1995 RxA: VATS surgery, no physiotherapy 1996-2000 RxB: VATS or open surgery, corticosteroid medication, pre-and postoperative chest physiotherapy. 2001-2005	Any of the following: • Bronchopneumonia • Aspiration pneumonia • Acute respiratory failure • Pleural effusion	C: 27% (14-46%) RxA: 36% (25-49%) RxB: 8% (4-15%)	28% (15-42%) NNT = 4 (2 to 7)	Patients who did not receive pre and postop physiotherapy were 4 times more likely to get a respiratory complication.
(Westwood et al 2007) England	Pre-post cohort Single centre	All elective and emergency UAS Mixed risk	263	n/a	C: Daily DB&C ex Rx: Daily DB&C ex + incentive spirometry	Presence of clinical features of collapse/ consolidation, plus one of the following: • Temp >38 • Positive CXR • Positive sputum	C: 17% (11-25%) Rx: 6% (3-12%)	11% (3-20%) NNT=9 (5-35)	The addition of incentive spirometry to chest physiotherapy may reduce PPCs following major UAS
Observational studies									
(Haines et al 2013) Australia	Prospective observational Single centre	High-risk elective and emergency UAS	72	n/a	Daily postop physiotherapy of early mobilisation, DB&C exercises, +/- NIV for 7 days	Melbourne group scale	39% (28-50%)	n/a	PPCs were 3 times more likely for each POD they did not mobilise away from the bed.
(Parry et al 2014) Australia	Prospective observational Single centre	High-risk elective and emergency UAS	50	n/a	Daily postop physiotherapy of early mobilisation, DB&C exercises, +/- NIV for 7 days	Melbourne group scale	42% (29-56%)	n/a	Patients with a nasogastric tube > 1 day were 9 times more likely to have a PPC
(Paisani et al 2012) Brazil	Prospective observational Single centre	Elective UAS Mixed risk profiles	137	n/a	Daily postop physiotherapy of early mobilisation and DB&C till hospital discharge	One or more of: • Pneumonia • Tracheobronchitis • CXR atelectasis with dyspnoea • Acute respiratory failure • Bronchoconstriction	7% (4-13%)	n/a	PPCs increase LOS and mortality.
(Feeney et al 2011) Ireland	Prospective observational Single centre	Elective oesophagectomy High-risk	37	n/a	Not specified	Melbourne group scale	27% (15-43%)	n/a	

(Chen et al 2011) Taiwan	Prospective observational Single centre	Elective oesophagectomy High-risk	68	n/a	Not specified	Any of the following: • Acute respiratory failure • Pneumonia • Pleural effusion	35% (25-47%)	n/a	
(Scholes et al 2009) Australia	Prospective observational Multi-centre	All elective UAS Mixed risk	268	n/a	All patients standardised to receive preop education and DB&C training and a single postop physiotherapy (early mobilisation and DB&C) session on POD1	Melbourne group scale	13% (10-18%)	n/a	ICU admission, length of surgery, preoperative estimated VO2max, upper GI surgery, and smoking predict PPCs.
(Browning et al 2007) Australia	Prospective observational Single centre	All elective UAS Mixed risk	50	n/a	All patients standardised to receive preop education and DB&C training and a single postop physiotherapy (early mobilisation and DB&C) session on POD1	Melbourne group scale	18% (10-31%)	n/a	Patients are upright for only 3-13 minutes a day for the first 3 postop days. Time upright predicted LOS, but not PPC risk.
(Kanat 2007) Turkey	Prospective observational Single centre	All elective UAS Mixed risk	60	n/a	Not specified. 95% achieved early mobilization as classified as <48hr post-op.	Any of the following: • Atelectasis • Pulmonary emboli • Bronchitis • Pneumonia • Pneumonitis • Acute respiratory failure	58% (46-70%)	n/a	
(Serejo et al 2007) Brazil	Prospective observational Single centre	All emergency UAS Mixed risk	266	n/a	Not detailed	Any of the following: • Atelectasis on CXR • Pneumonia • Pleural effusion • Acute respiratory failure	28% (23-34%)	n/a	

Notes: ARR, absolute risk reduction; ASA, American association of anaesthesiologists; AAA, abdominal aortic aneurysm; BiPAP, bi-level positive airway pressure; BMI, body mass index; C, control; CI, confidence interval; CXR, chest Xray; DB&C, deep breathing and coughing; GI, gastrointestinal; ICU, intensive care unit; IMT, inspiratory muscle training; Intraop, intraoperatively; LOS, length of stay; MIP, maximal inspiratory pressure; n/a, not applicable; NNT, number needed to treat; NIV, non-invasive ventilation; PEP, positive expiratory pressure; POD, postoperative day; Postop, postoperatively; PPC, postoperative pulmonary complication; Preop, preoperatively; RPE, rate of perceived exertion; Rx, treatment; UAS, upper abdominal surgery; VATS, video assisted thoracic surgery; WCC, white cell count.

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