The current use of positive expiratory pressure (PEP) therapy by public hospital physiotherapists in New South Wales

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ABSTRACT

Positive expiratory pressure (PEP) therapy involves the application of a resistance to expiration to produce positive airway pressure. PEP therapy is an effective treatment strategy; however, little is known about its current clinical use. The purpose of this study was to describe the clinical use of PEP therapy. The study was a cross sectional design using a written survey. Participants were physiotherapists from public hospitals in New South Wales, Australia (n=149). The response rate was 60% (n=89). PEP therapy was regularly used in the clinical practice of 68 (76%) respondents. The patient group most frequently treated with PEP therapy were those with respiratory medical conditions (n=59, 87%) and the most commonly selected indication for use was excessive respiratory secretions (n=60, 88%). Improvised devices such as bubble (or bottle) PEP were used by more respondents (n=61, 90%) than commercially-available devices (n=30, 44%) and were constructed using a variety of methods, often non-standardised. PEP therapy (particularly variably constructed bubble-PEP) was regularly employed for the treatment of patients with cardiorespiratory conditions. Further research into the effectiveness of PEP delivered with improvised devices and more specific training of healthcare practitioners regarding optimal design parameters for PEP therapy may be beneficial.

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INTRODUCTION

Positive Expiratory Pressure (PEP) therapy involves the application of a resistance to expiration in order to produce positive airway pressure (Darbee et al 2004). Positive expiratory airway pressure is thought to stabilise airways, prevent premature airway closure, improve ventilation and reduce gas trapping (Darbee et al 2004, Lannefors et al 1992, McIlwaine et al 2001, O'Neill et al 2002). PEP therapy has been used, and is recommended, as a component of respiratory physiotherapy management for varying adult and paediatric patient groups including those with cystic fibrosis (Lagerkvist et al 2006, McIlwaine 1997, McIlwaine 2001), acute and chronic respiratory disease (Bjorkqvist et al 1997, Brooks et al 2003, Hill et al 2010, Langer et al 2009, Lee et al 2008, Tang et al 2010), and in the post-operative setting (Campbell et al 1986, Orman and Westerdahl 2010, Urell et al 2011). Improvements in secretion clearance, functional residual capacity and oxygenation have been demonstrated with the use of PEP therapy (Darbee et al 2004, Mortensen et al 1991, Urell et al 2011). PEP therapy has been positively compared with conventional chest physiotherapy; however, there is currently inadequate evidence to indicate whether it is any more effective than other forms of treatment such as postural drainage and percussion, particularly in terms of secretion clearance (Elkins et al 2006, Olsen and Westerdahl 2009).

There are a variety of devices available for the provision of PEP therapy including several commercial systems. Other PEP therapy options include simple improvised devices (including "bottle/bubble"-PEP) which can be constructed from accessible, low-cost materials and are an inexpensive alternative to commercial appliances (Bjorkqvist et al 1997, Fiore et al 2010, Mestriner et al 2009). Both commercial and improvised devices enable the creation of positive pressure on expiration, with optimal settings recommended between 10-20cmH_2O (McCool and Rosen 2006, Myers 2007). PEP devices are either flow-resistor or threshold-resistor in type (Mestriner et al 2009). Many commercial PEP devices are flow-resistors with expiration occurring through a fixed orifice and the positive pressure generated varying with the expiratory airflow (Mestriner et al 2009). Bottle or bubble-PEP devices are examples of threshold-resistors, where the expiratory positive pressure remains constant if tubing diameter and length are adequate (Mestriner et al 2009). Improvised devices are commonly used clinically (Bjorkvist et al 1997, Lee et al 2008, Sehlin et al 2007) and parameters have been published for the construction of these devices to enable them to function as threshold-resistors and achieve an adequate level of positive pressure (Mestriner et al 2009).

PEP therapy is a recommended and effective component of the management of people with respiratory pathology; however, there is little information about the actual clinical usage of the technique, particularly the use of improvised PEP devices. There is little definition of the patient groups most commonly prescribed PEP therapy, the methods of administration, the systems used and the means of construction of improvised devices, including adherence to appropriate design parameters. The aim of this project was therefore to describe the current clinical use of PEP therapy (in particular the use of improvised PEP devices) by public hospital physiotherapists in New South Wales.

METHODS

Study Design

The study was a cross sectional design using a custom designed anonymous written survey.

Survey Instrument

As no published or validated tool existed with which to determine the clinical practice of PEP therapy, a written survey was custom designed. The survey contained 35 questions in four sections: demographics, current clinical use of PEP therapy, equipment used and background rationale. The majority of questions were in closed categorical form with some open-ended written questions included to allow for answer clarification. Improvised devices consisting of a tube and a liquid container were designated "bubble" rather than "bottle"-PEP as this terminology is more commonly used in Australia.

Participants

Participants were physiotherapists working in New South Wales (NSW) public hospitals. The public listings of hospitals on the NSW Department of Health website (www.health.nsw.gov.au) were reviewed. Of the 228 public hospitals identified, 149 were noted to have a physiotherapy department. A single representative from each of these sites was invited to participate. Packages were addressed to the "senior respiratory physiotherapist" for metropolitan/large regional hospitals and to the "senior inpatient physiotherapist" for smaller regional/rural hospitals. Apart from stipulating who should complete the survey, no other selection criteria were applied and there were no exclusion criteria.

Procedure

Each identified site was sent a package containing a participant information letter (including completion instructions), a copy of the survey, a postage-paid site identification card and a reply-paid envelope. The participants were requested to return both the survey and site-identification card (even if they chose not to complete the survey). Return of the survey was taken to constitute informed consent. The site-identification cards were used to track returns and maximise response rate. A reminder letter and a second package were sent one month after the original mail out to all who had not returned site identification cards.

Data Analysis

All data were collated and analysed using the SPSS statistics package (version 19, SPSS Inc Chicago Il.). All closed categorical responses were analysed using frequencies and percentages. Categorical demographic variables of PEP and non-PEP users were compared using contingency tables, chi-squared analysis or Fisher's exact test when cell counts were small.

RESULTS

Response Rate, Participant and Site Demographics

There were 89 completed surveys returned, a response rate of 60%. Respondent and site demographics are displayed in Table 1.

Table 1: Site and respondent demographics for PEP Therapy (n=68, 76%) and non-PEP Therapy users (n=21, 24%). Total respondents n=89.

	PEP users	Non PEP users	Total
Highest qualification	n (%)	n (%)	n (%)
Diploma	9 (13)	4 (19)	13 (15)
Bachelor's degree	50 (74)	14 (67)	64 (72)
Master's degree	8 (12)	3 (14)	11 (12)
Doctorate	1 (2)	0 (0)	1 (1)
Years of clinical experience			
< 1	1 (2)	0 (0)	1 (1)
1 - 5	14 (21)	1 (5)	15 (17)
5 - 10	12 (18)	2 (10)	14 (16)
> 10	41 (60)	18 (86)	59 (66)
Years of experience in cardiorespiratory physiotherapy			
< 1	3 (4)	0 (0)	3 (4)
1 - 5	14 (21)	7 (33)	21 (24)
5 - 10 years	22 (32)	3 (14)	25 (28)
> 10 years	29 (43)	11 (52)	40 (45)
Hospital size (beds)*			
< 50	25 (37)	14 (67)	39 (44)
50 - 100	12 (18)	6 (28)	18 (20)
100-200	15 (22)	0 (0)	15 (17)
200 - 500	12 (18)	1 (5)	13 (15)
>500	4 (6)	0 (0)	4 (5)

* $p<.05$

Clinical Use of PEP Therapy

PEP therapy was used in the current clinical practice of 68 (76%) of the total respondents (n=89), and was not used clinically by 21 (24%). While those who did not use PEP in their current clinical practice formed a larger proportion of the respondents who worked in smaller rural locations, there were no significant differences found between PEP users and non-PEP users in terms of entry-level qualification, years of experience, years of experience in cardiorespiratory physiotherapy or hospital location. Significant differences were identified between PEP and non-PEP users in regard to number of hospital beds (p = 0.013) with non-PEP users more commonly working in hospitals with smaller bed numbers. No further analysis of the non-PEP users was undertaken.

PEP therapy was used regularly with 41 (60%) respondents using it at least weekly and 17 (25%) daily. The patient group most commonly treated with PEP was classified "respiratory medicine (exclusive of cystic fibrosis)" (n=59, 87%), followed by patients with cystic fibrosis (n=28, 41%) and paediatrics (n=4, 6%). Following initial prescription, 54 (79%) respondents indicated that patients performed PEP therapy either mostly, or fully, independently.

The most commonly selected indication for using PEP was excessive secretions (n=60, 88%), followed by alveolar

collapse (n=29, 43%), persistent alveolar collapse (n=20, 29%), prevention of respiratory complications (n=11, 16%) and reduction of shortness of breath (n=8, 12%). Four (6%) respondents stated that PEP was indicated to provide a visual "reminder" for patients to do their prescribed exercises.

The amount of positive pressure most commonly reported was 10-20cmH_2O (n=43, 63%) followed by <10cmH_2O (n=5, 7%). Thirty four respondents (50%) reported that their site had a protocol for the use of PEP and 53 (78%) respondents indicated that their site had stipulated parameters for PEP treatment (Table 2). Almost all (n=60, 88%) respondents reported that they would commonly combine PEP with other cardiorespiratory treatment techniques in a single treatment session (Figure 1).

Table 2: PEP therapy treatment parameters, specified by those respondents with site stipulated dosage protocols (n=53).

Parameter	n (%)
Repetitions	
3-5 breaths	20 (38)
6-10 breaths	20 (38)
>10 breaths	6 (11)
Did not specify	7 (13)
Sets	
1-2 sets	5 (9)
3-5 sets	18 (34)
6-10 sets	9 (17)
> 10 sets	3 (6)
Until clear	2 (4)
Did not specify	16 (30)
Times per day	
1-2 times	4 (8)
3-5 times	23 (42)
Every 2 hours	4 (8)
Every hour	9 (17)
Individual for each case	4 (8)
Did not specify	9 (17)

Equipment Used for PEP Therapy

Improvised devices were more commonly used in the clinical setting than commercially available devices (Table 3). Twenty two (32%) respondents reported that therapists used both commercial and improvised devices at their site. Details of equipment used for improvised PEP devices are presented in Table 4. Sealed containers were used by 37 (54%) respondents. The routine use of a pressure manometer when prescribing PEP therapy was reported by 13 (19%) respondents.

DISCUSSION

This is the first study to specifically document the clinical use of PEP therapy, particularly the use of improvised devices. The main findings were that PEP was regularly used by public hospital physiotherapists, was frequently combined with other

Figure 1: Other techniques reported to be used in combination with PEP Therapy.

Other techniques reported to be used in combination with PEP therapy as specified by respondents included: Autogenic Drainage (n=1), cough assist machine (n=1), Flutter (n=1), incentive spirometry (n=1), increase fitness (n=2), manual cough assist (n=1), suction (n=1).

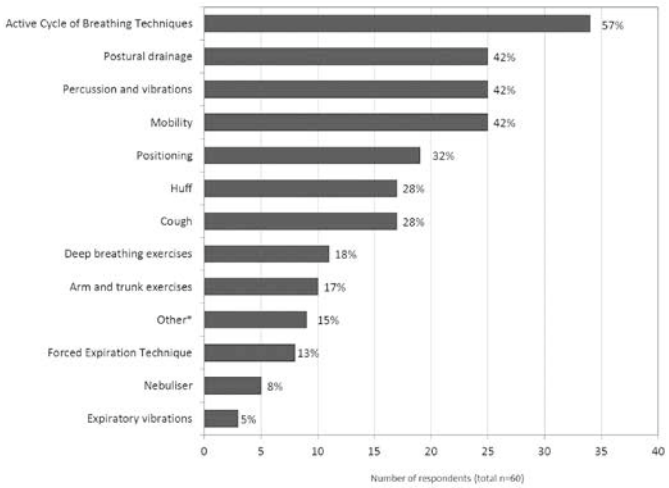

Table 3: PEP devices reported to be used in clinical practice (n=68)

	n (%)
Commercially available PEP devices	
PARI PEP®	15 (22)
Astra PEP/RMT™	9 (13)
Therapep®	4 (6)
Other (as specified by respondents)	15 (22)
Threshold®PEP	8 (12)
Non-commercial (self-made) PEP devices	
"Bubble-PEP"	61 (90)
"Non-bubble PEP (including PEP tubes)"	9 (13)

cardiorespiratory treatment techniques and was most often used in the management of patients with medical respiratory conditions. Improvised PEP devices (such as bubble-PEP) were more commonly used than commercially available devices and the construction of these devices was varied.

Many respondents regularly used PEP therapy as part of their day-to-day clinical practice. Those who reported not using PEP tended to have more years of general experience and were working in smaller hospitals. The reasons for this are unknown as the respondents' rationale for choosing to use or not use PEP was not canvassed in this study. More years of experience would indicate a longer time since completion of entry-level qualifications and possibly the use of PEP may not have been included in the entry-level curricula of these respondents. Hospitals with smaller bed numbers are often situated in rural or smaller regional areas and clinicians working in these settings may not use PEP due to a lack of specialised training or due

Table 4: Equipment used to construct self-made PEP systems as reported by respondents who used this type of PEP therapy. Respondents were permitted to choose more than one response.

	Bubble PEP (n=61)	Non-bubble PEP (n=9)
Type of water container	n (%)	n (%)
Water for irrigation	22 (36)	-
Drink bottle	17 (28)	-
Sterile water	8 (13)	-
Saline bottle	8 (13)	-
Milkshake container	2 (3)	-
Wall mounted suction bag	1 (2)	-
Patient's water jug	1 (2)	-
Missing	2 (3)	-
Volume of container (ml)		
500	10 (17)	-
600	5 (8)	-
1000	12 (20)	-
1250	2 (3)	-
2000	8 (13)	-
Missing	24 (39)	-
Type of tubing		
Oxygen tubing	37 (60)	7 (78)
Suction tubing	18 (30)	0 (0)
Drinking straw	4 (7)	0 (0)
Chest drain tubing	2 (3)	0 (0)
Syringe	-	4 (44)
Other tubing	-	2 (22)
Tubing Length (cm)		
10	0 (0)	2 (22)
15	9 (15)	0 (0)
20	24 (39)	4 (44)
25	3 (5)	0 (0)
30	7 (12)	1 (11)
>30	11 (18)	0 (0)
Did not specify	7 (11)	2 (22)
Diameter of tubing(cm)		
0.5	9 (15)	2 (22)
1	39 (63)	4 (44)
1.5	3 (5)	0 (0)
Did not specify	10 (17)	3 (34)

to resource constraints (such as availability of finances for equipment or access to services such as on site sterilisation), issues commonly facing rural/remote healthcare practitioners. Further specific training for relevant healthcare practitioners in the use of PEP may be beneficial.

The pattern of use of PEP therapy reported by respondents in this study appears to be largely consistent with that of the published research relating to the technique. Those who reported using PEP mainly used it in the management of patients with medical cardiorespiratory conditions (acute and chronic), mostly in combination with other techniques and primarily with the aim of clearing excessive secretions. Most studies into the effectiveness of PEP have been undertaken in patients with cystic fibrosis (Darbee et al 1994, Lannefors et al 1992, McIlwaine et al 1997, McIlwaine et al 2001); however, its use has also been recommended for those with other conditions (such as chronic obstructive pulmonary disease and pneumonia) often characterised by excessive respiratory secretions (Bott et al 2009, Hill et al 2010, Langer et al 2009, Olsen and Westerdahl 2009). Other studies have reported that positive pressure therapy (including PEP) was used by clinicians to manage atelectasis (Fiore et al 2010). Respondents in our study reported using PEP for the treatment of alveolar collapse; however, it is not clear whether this relates to alveolar collapse seen as a result of post-operative respiratory dysfunction. Post-operative patients were not a group specified by respondents in this study as being commonly treated with PEP therapy. The inclusion of PEP in the management of post-operative patients has been investigated (Campbell et al 1986, Orman and Westerdahl 2010, Urell et al 2011); however, there is less information about this aspect of the technique.

Respondents reported that they commonly combined PEP therapy with other cardiorespiratory physiotherapy treatment techniques. There is limited evidence about the practice or effectiveness of using PEP in combination with other treatment techniques. Most commonly, PEP has been studied as an independent technique in comparison to conventional chest physiotherapy; however, it has also been investigated in combination with forced expirations or the Forced Expiratory Technique (FET) (Hofmeyer et al 1986, McIlwaine et al 1997, McIlwaine et al 2001). The survey respondents reported that they used PEP therapy more commonly in combination with postural drainage and the Active Cycle of Breathing Techniques (ACBT) than with the FET. How common the practice of combining PEP with other techniques internationally is unknown and warrants further investigation.

The most commonly reported dosage parameters were 3-5 sets of 3-10 breaths, performed 3 to 5 times each day with PEP levels of 10-20 cmH_2O, all broadly consistent with published research (Olsen and Westerdahl 2009, Orman and Westerdahl 2010). However, despite respondents reporting the use of defined dosage parameters consistent with recommendations, whether healthcare practitioners actually measure the level of PEP in their clinical practice is unknown. The low reported use of manometers for prescription of treatment would indicate that PEP levels are not frequently measured, a not unexpected finding given the high reported use of self-made devices.

Non-commercial devices for PEP therapy were more commonly used than commercially available devices by the respondents in this study. Questions relating to the respondents' rationale for their choice of device were not included in the current survey so it is not clear why this means of delivering PEP was chosen. Reasons may include a lack of specific training with commercially available devices and/or resource limitations. Many commercial devices are quite expensive and/or require sterilisation for between-patient use. The option of a simple self-made device which can be cheaply constructed for single-

patient use would be attractive in a climate of limited healthcare financial resources. However, the potential for poor effectiveness or patient harm is higher when non-standardised improvised devices are constructed and used.

The most commonly used form of non-commercial device reported in this study was bubble-PEP. Use of bubble-PEP has been reported in Sweden (Bjorkqvist et al 1997, Sehlin et al 2007), Australia and New Zealand (Lee et al 2008), and the United Kingdom (O'Neill et al 2002). A survey of general physiotherapy clinical practice in Australia and New Zealand (Lee et al 2008) found that 50% of locations surveyed used PEP devices for the treatment of patients with chronic obstructive pulmonary disease and bronchiectasis and 76% of locations used bubble-PEP in such treatment. The present study also confirms that bubble-PEP is commonly used clinically; however, there is very little published research regarding the effectiveness of this technique in clinical practice.

Respondents in the current study reported using a diverse range of materials and methods to construct bubble-PEP devices. Bubble-PEP devices need to be accurately constructed to deliver the prescribed level of positive expiratory airway pressure. Differences between commercially available PEP masks and improvised bubble-PEP in terms of physiological parameters such as airflow and airway pressure have been demonstrated (Sehlin et al 2007). Bubble-PEP devices that do not conform to correct design parameters may deliver inappropriate levels of PEP and may be hazardous for patients, for example by increasing work of breathing (Mestriner et al 2009, Sehlin et al 2007).

Recommendations regarding the optimum design parameters for a bubble-PEP device have been published. In order to achieve the desired PEP level of 10-20cm H_2O, Mestriner et al (2009) recommend the use of 10cm of liquid, 20cm of tubing of at least 8mm diameter and sealing of the device with an 8mm or greater escape orifice. In the current study, the most commonly reported tubing specifications corresponded with the recommended parameters. However, despite many respondents reporting the use of 1cm diameter tubing, these same respondents reported that they were most commonly using "oxygen" tubing. The diameter of standard commercial oxygen tubing is usually less than 0.8cm (for example, 0.55cm) (APS Medical 2009), the use of which may result in a higher level of PEP than recommended.

A large number of respondents reported using liquid containers such as drink bottles, which are not standardised particularly with respect to the air-escape orifice (Mestriner et al 2009). Several respondents also reported using other improvised non-bubble PEP therapy devices (including "PEP-tubes"), which were also variably constructed. Given the apparent common clinical use of improvised PEP therapy and the variety of methods used in construction of the devices, further research into the use and effectiveness of this form of therapy with a variety of patient groups is essential. It would also be of interest to compare adherence to optimal design parameters internationally.

Along with the lack of standardisation in construction, another issue of concern is that improvised bubble-PEP devices require receptacles containing liquid to be present at the bedside, possibly for extended periods. This may be an infection control risk. Standing liquid which is not changed regularly has the potential to be a source of pathogens (Gould et al 2005). Liquid containers remaining at the bedside also add to clutter and may compromise the safety of electrical equipment. In addition, patients with impaired airway protection mechanisms (for example poor glottic closure or ineffective cough) may also be at risk of aspiration either during bubble-PEP treatment or due to inadvertently attempting to drink the water from the container.

The response rate for this study was 60% which is consistent with literature and commonly deemed acceptable (Cook et al 2005, Livingstone and Wislar 2012). It is unknown as to whether the non-responders were different from the responders. Those responding to the survey had a wide range of clinical experience and represented diverse geographical settings. The profile of respondents, in terms of years of experience, is typical of the population of physiotherapists practicing in NSW (AIHW 2006). Responses were received from all geographical areas including rural, regional and metropolitan settings and the proportion of respondents working in small hospitals compared to larger sites was also commensurate with state-wide data (AIHW 2009).

One of the limitations of the study may be a response bias due to surveys being completed by only one therapist at each site. However, most of the questions required factual answers rather than personal opinion and it is unlikely that others working in the same site would have different PEP protocols. Healthcare practitioners working in other settings such as community health, private hospitals or private practice were not included in the study and their inclusion in further research may yield useful information.

CONCLUSION

This study has shown that PEP therapy is a technique commonly used by physiotherapists for the treatment of patients with cardiorespiratory conditions. General parameters for use were consistent with published research and improvised devices were more commonly used than commercially available devices. Bubble-PEP devices were the non-commercial devices most frequently used and were constructed using a variety of materials and methods with little standardisation. The widespread use of bubble-PEP needs to be considered in the light of the potential hazards to patients due to non-standardised construction methods, inadequate measurement of airway pressure delivered during treatment, and infection control risks. This study highlights the need for more research about the effectiveness of PEP delivered with improvised devices, such as bubble-PEP, and indicates that more specific training of healthcare practitioners regarding the clinical use of PEP therapy may be required and beneficial.

KEY POINTS

- Positive Expiratory Pressure (PEP) therapy is an effective technique commonly used by physiotherapists in the management of people with cardiorespiratory dysfunction. PEP therapy may be delivered via commercial or non-commercial devices (including simple improvised devices such as "bottle/bubble"-PEP) however there is little information about the actual clinical usage of PEP therapy.
- This study describes the current clinical use of PEP therapy. PEP therapy was found to be regularly used by public hospital physiotherapists with improvised devices (such as bubble-PEP) more commonly used than commercially available devices.
- The construction of these devices was variable and frequently non-standard. This raises concerns regarding effectiveness and potential impact

on patient safety. Further research regarding the use of PEP therapy delivered with improvised devices, such as bubble-PEP, is necessary.

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PERMISSIONS

Ethical approval for this study was granted from The University of Newcastle, Australia, Human Research Ethics Committee (Reference number H-2009-0162).

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