DR. EVE J DENTON (Orcid ID : 0000-0003-1482-7626)

PROF. MARK HEW (Orcid ID : 0000-0002-7498-0000)

Article type : Letter to the Editor

Breathing pattern disorder in difficult asthma: characteristics and improvement in asthma control and quality of life after breathing re-training

To the Editor:

Breathing pattern disorder (BPD), or dysfunctional breathing, encompasses heterogeneous disorders characterised by abnormal breathing patterns resulting in symptoms that mimic asthma. (1) BPD affects 24-29% of patients with asthma and 30-64% of patients with difficult asthma. (1-4) Diagnosis is generally based on Nijmegen score, a questionnaire that detects hyperventilation, just one BPD form. (1, 4, 5) Difficult asthma is distinct from severe asthma (6) and patient factors including comorbidities such as BPD are thought to be particularly important in patients with difficult asthma.

In primary care, breathing retraining for patients with asthma improves quality of life (QOL). (7) Patients with difficult asthma present a much greater health burden and BPD is independently associated with worse asthma control and QOL, therefore, treatment may deliver a greater benefit. (8)

This study, in patients with difficult asthma, examines BPD characteristics and reports outcomes following breathing retraining.

This is the author manuscript accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the [Version of Record](#). Please cite this article as [doi: 10.1111/all.13611](https://doi.org/10.1111/all.13611)

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We undertakesystematic evaluation for difficult asthma,(9)where patients with suspected BPD undergoa multidimensional physiotherapistassessment. Ethics approval was obtained (HREC 185/15); requirement for informed consent was waived.

Nijmegen, Asthma Control Test (ACT),andAsthma QOL Questionnaire (AQLQ) were administered at baseline and six months. Asthma exacerbations were definedas ≥ 3 days systemic corticosteroids. Inhaler technique and adherence were assessed and optimised.

Asthma comorbidities weresought;allergic rhinitis—symptoms and atopy; chronic rhinosinusitis—clinical symptoms withabnormal sinus CT or rhinological examination;anxiety and depression—physician diagnosisor elevated Hospital Anxiety and Depression score (HADS); andvocal cord dysfunction —paroxysmal vocal cord movement on nasoendoscopy.

Patients with suspected BPD were assessed by aspecialised physiotherapist for mouth breathing, thoracic dominance, hyperventilation (elevated respiratory rateat rest), thoracoabdominal asynchrony, accessory muscle use and musculoskeletal abnormalities. Breathing retrainingwas delivered over one or more sessions. A general therapeutic approachcomprised promotion of abdominal and nose breathing, postural training,relaxation, and feedback to consciously decrease the respiratory rate,tailored to individual BPD features detected at assessment.

Of 109consecutive patients assessed between June 2015 and December 2017, 35underwent BPDevaluation. 29/35 patients were diagnosed with BPD(patient characteristics *Table 1*). 25 had documented variable airflow obstruction (*Table 1*);3had a clinicalasthma diagnosisand one had fixed airflow obstruction (never smoker).

The mean number (and standard deviation) of exacerbations in the prior six months was 3.1 ± 2.3 , ACT score 13.1 ± 4.3 , AQLQ score 3.9 ± 1.1 , and reliever use over seven days 24 ± 43 actuations.

Comorbidities were frequent; allergic rhinitis in 38%, chronic rhinosinusitis in 48%, anxiety/depression in 62%, and vocal cord dysfunction in 31%.

Mean baseline Nijmegen score: $28.8 \pm 12.7/29$ (24%) patients had normal scores (<24). The commonest BPD characteristic was thoracic dominance (83%), with prominent excursion of the upper chest at rest rather than the abdomen, a highly inefficient method of breathing. Hyperventilation was present in 45%, mouth breathing 28%, accessory muscle use at rest 24%, spinal abnormalities 10%, abnormal neck position 10%, and thoraco-abdominal asynchrony 3.5%. There was considerable BPD characteristic overlap (Figure 1).

Following breathing retraining, of the 23 patients with pre and post scores available, mean Nijmegen score improved significantly; 30 to 21 ($n=23$ $p<0.001$), 21 improved, one remained stable and one worsened. 11/23 patients normalised their initially elevated scores. 10/23 were 'super-responders' (>10 point improvement), not all of these patients had elevated scores initially. Physiotherapy assessment revealed improved breathing technique in most patients.

Among patients with available post-treatment scores, there was a significant improvement in mean ACT (13 to 16, $n=21$, $p=0.018$), and AQLQ (from 3.9 to 4.7, $n=25$, $p=0.001$) but not in anxiety (HADS-A; 8.3 to 8.9, $n=20$, $p=0.44$) nor depression scores (HADS-D; 6.2 to 6.8, $n=21$, $p=0.28$). Exacerbations decreased significantly from 2.8 to 1.4, $n=17$, $p=0.006$. This was despite there being no significant change in FEV1 following breathing re-training ($n=27$, $p=0.81$). Negative or positive baseline Nijmegen score did not impact on these improvements.

This study of patients with difficult asthma and BPD demonstrates substantial disease heterogeneity and BPD characteristic overlap. Thoracic dominant breathing was the

93 commonest BPD pattern, but this often co-existed with hyperventilation and mouth
94 breathing. Postural and musculoskeletal abnormalities were also seen in this population,
95 and may contribute to BPD development. There was a mean 30 years since asthma diagnosis
96 amongst our patients and this may be an important factor in development of BPD.

97
98 Individuals with asthma often have residual symptoms despite optimal pharmacological
99 therapy. BPD may account for some of these residual symptoms and associated disease
100 burden. (10) Breathing retraining improves QOL in individuals with asthma. (7) Among our
101 patients with difficult asthma, the majority responded to breathing retraining by a specialised
102 physiotherapist. Following breathing re-training there were significant improvements in
103 asthma control, QOL, Nijmegen scores and fewer asthma exacerbations. There was also
104 visible improvement in breathing techniques in most patients. Mood disorder was common
105 in this group however there was no specific treatment for anxiety or
106 depression administered during the study period. The benefits of breathing re-training in
107 BPD do not appear to be modulated by improvements in depression or anxiety, as the HADS
108 scores remained static.

109
110 A quarter of our patients with physiotherapist-confirmed BPD had normal baseline
111 Nijmegen scores, indicating that more sensitive diagnostic tools are needed to detect other
112 forms of BPD in addition to hyperventilation.

113
114 These data are attended by the usual constraints of an uncontrolled single-arm
115 observational study. Questionnaire follow-up was incomplete, raising the possibility of bias
116 when assessing response to treatment. BPD assessment was undertaken by a single
117 specialised physiotherapist and therefore inter-rater reliability is not available. Three
118 patients had a clinical asthma diagnosis and may have been misclassified. This is a highly
119 selected population and therefore results are not applicable to a general asthma population.
120 Some BPD characteristics may represent maladaptive learned responses to airways
121 obstruction; nevertheless as we have shown they are responsive to therapy we feel that it is
122 important to recognise and treat these characteristics.

In conclusion, BPD was common in a difficult asthma cohort, and there was significant overlap of different BPD characteristics. In this patient group, breathing retraining was effective therapy for BPD, associated with improvements in asthma outcomes.

Conflicts of interest: There are no conflicts of interest reported for any author related to this paper.

Table 1: Baseline demographic data

Age (mean +/- standard deviation)	49 +/- 12 years
Sex (% female)	59%
BMI (mean +/- standard deviation)	31±6.7 kg/m ²
FEV1 % predicted (mean +/- standard deviation)	71± 22
Variable airflow obstruction	25/29 (86%)
Bronchodilator reversibility	16/29 (55%)
Peak flow variability	6/29 (21%)
Bronchial hyperreactivity	3/29 (10%)
Years since asthma diagnosis (mean +/- standard deviation)	30 ±17.8
Serum eosinophils (mean +/- standard deviation)	0.19 ± 0.16 x 10 ⁹ /L
Total IgE (mean +/- standard deviation)	428 ± 997 kU/L
Smoking status: Never	69%
Ex	24%
Current	7%
Employed	59%

Figure 1: Breathing pattern disorder characteristics overlap significantly in patients with difficult asthma.

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Breathing pattern disorder in difficult asthma: characteristics and improvement in asthma control and quality of life after breathing re-training

Eve Denton^{1,2}, Janet Bondarenko³, Robyn E O’Hehir^{1,4}, Mark Hew^{1,2}

¹*Allergy, Asthma & Clinical Immunology, The Alfred Hospital, Melbourne,*

²*Public Health & Preventive Medicine, Monash University,*

³*Physiotherapy Department, The Alfred Hospital, Melbourne,*

⁴*Central Clinical School, Monash University*

Corresponding author:

Eve Denton

Allergy, Asthma and Clinical Immunology, Respiratory Medicine

The Alfred hospital

55 Commercial Road, Melbourne, VIC 3004, Australia

+61390762000

e.denton@alfred.org.au

Conflicts of interest: There are no conflicts of interest reported for any author related to this paper.

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202 **Word count:** 996

203

204

205 **Key words:**

206 Breathing pattern disorder

207 Dysfunctional breathing

208 Asthma

209 Difficult asthma

210 Severe asthma

211 Breathlessness

212

213

214 **Author contributions:**

215 *Eve Denton*: data collection, data analysis, manuscript write up

216 *Janet Bondarenko*: contribution to manuscript content, significant editorial assistance

217 *Robyn O’Hehir*: significant editorial assistance, manuscript writing and re-drafting

218 *Mark Hew*: significant editorial assistance, manuscript writing and re-drafting

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Mouth breathing 28%

Hyperventilation 45%

Accessory muscle use 24%

Spinal abnormality 10%

Thoracic dominance 86%

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Author/s:

Denton, E;Bondarenko, J;O'Hehir, RE;Hew, M

Title:

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Date:

2019-01

Citation:

Denton, E., Bondarenko, J., O'Hehir, R. E. & Hew, M. (2019). Breathing pattern disorder in difficult asthma: Characteristics and improvement in asthma control and quality of life after breathing re-training.. *Allergy*, 74 (1), pp.201-203. <https://doi.org/10.1111/all.13611>.

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