Comparing Breathing Intolerance (BIT) Indices
Pre- and Post-Diaphragmatic Muscle Fatigue in Healthy Adults

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Abstract:
Breathing Intolerance Index (BIT Index) was proposed by Dr. Toshihiko Koga as an alternative to measuring the Time Tension Index of the diaphragm (TTIdi) to measure diaphragmatic fatigue. BIT Index is defined as Inspiratory Time/Total Time multiplied by Dynamic Minute Volume/Capacity (Ti/Ttot x (Vt/VC)). This report is the result of using BIT Index to determine if diaphragmatic fatigue is present and if ventilatory assistance is indicated or not. The authors would also like to thank Dr. Nirmal Charan for his support, guidance and assistance.

Introduction:
Breathing Intolerance Index (BIT Index) was proposed by Dr. Toshihiko Koga as an alternative to measuring the Time Tension Index of the diaphragm (TTIdi) to measure diaphragmatic fatigue:

BIT Index = (Ti/Ttot) x (Vt/VC), where:

- Ti = inspiratory time
- Ttot = total time of the breath
- Vt = tidal volume
- VC = vital capacity

Dr. Koga assessed subjects who used Noninvasive Positive Pressure Ventilation (NPPV) at night for Obstructive Sleep Apnea and found that they had a higher BIT Index when compared to healthy adults. Currently, there is no recognized scale comparable to the BIT Index. Additionally, there is a lack of evidence indicating that the BIT Index changes.

Methods:
Following Boise State University Institutional Review Board (IRB) approval, four female subjects, without known pulmonary disease, read and signed the informed consent. Baseline Vt, Ti, Ttot and Maximal Inspiratory Pressure (MIP) were measured using the METEOR Respiratory Mechanics Handheld Monitor (Cardiopulmonary Technologies, Inc.). The baseline BIT Index was calculated for each subject. These values were measured at least twice to demonstrate reproducibility. The level of dyspnea was rated per the Modified Borg Scale.

Results:
Inducing diaphragmatic fatigue proved difficult. Subjects 1 and 2 reached diaphragmatic fatigue in less than 40 minutes; their BIT Index increased, their MIP decreased, and their Vt/VC increased. Subject 3 required the longest time (77 minutes) to reach peak dyspnea, and her BIT Index decreased. Subject 4 had no change in her BIT Index, but ended the testing period sitting in a tripod position after 57 minutes. It is interesting to note that Subject 3 exercises regularly and Subject 4 practices yoga; the BIT Index did not increase in either of these subjects.

Conclusion:
Dr. Toshihiko Koga postulated that the Breathing Intolerance Index may be used to guide our patients' ventilatory management. He believed that it may be implemented to help determine if diaphragmatic fatigue is present and if ventilatory assistance is indicated or ventilatory support may be discontinued.

When the BIT Index is increased, the patient is using a greater percentage of the vital capacity for normal breathing and/or the patient is spending a greater percentage of the total time in inspiration and less in expiration. If the patient is using a greater percentage of the tidal volume for normal breathing, the patient's inspiratory reserve volume and/or the expiratory reserve volume are reduced. Because the diaphragm rests during expiration, as expiratory time is reduced, the likelihood of diaphragmatic fatigue increases. Each of these situations can result in increased diaphragmatic fatigue.

Further studies are needed to determine if the BIT Index is indeed an indicator of diaphragmatic fatigue, and if so, how to apply the BIT Index to the clinical setting to assist in the evaluation of patients with muscle fatigue and/or muscle weakness. Alternate methods of inducing diaphragmatic fatigue need to be explored. In addition, a larger group of study participants is needed to strengthen the investigation of the BIT Index and to determine the relationship between the BIT Index and muscle weakness and/or muscle fatigue.

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References:

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