The relationship between Airway Pressures and Airway Flow using Incentive Spirometry

Suthawan Anakmeteeprugsa[1] MD , Gudrun Maria Jonsdottir[1] MD MSc, Amy Jacob[2] BSc , Kirk H Shelley, MD PhD[1], Aymen Alian[1] MD.

1 Yale School of Medicine, New Haven, Connecticut, USA. 2 City University of New York (CUNY) School of Medicine, New York, New York, USA.

Background: Diaphragmatic dysfunction is a potential complication of brachial plexus block (BPB). It has been shown that the incidence of diaphragmatic dysfunction can be 100% after interscalene BPB[1] and as high as 50-67% with supraclavicular BPB[2,3]. There are multiple modalities to assess diaphragmatic dysfunction such as plain radiographs, ultrasound, fluoroscopy and pulmonary function tests[4]. Pere *et* al. showed a clearly decreased diaphragmatic motion after continued interscalene BPB accompanied with restrictive changes observed on spirometry, measured as maximal inspiratory and expiratory pressures[5]. Incentive spirometer (IS) is an inexpensive and widely used device in the perioperative period, but it measures airway flow. The aim of this study is to assess the patient´s effort of breathing (generating negative airway pressure) and airway flow on IS before and after BPB.

Methods: This prospective observational study included all adult patients scheduled to undergo BPB for upper extremity surgery. Patients with pre-existing neuromuscular disease and/or diaphragmatic pathology were excluded. After informed consent, the patients were instructed on how to use an IS, connected to a pressure transducer. The IS has three balls and each ball presents flow volume, with three balls representing 1200 mL/sec, two balls 900 mL/sec and one ball equal to 600 mL/sec (Figure 1-A). The patients were instructed to take eight breaths through the IS before and after BPB and the maximum negative inspiratory pressure and airway flow were recorded. Data was entered into Excel® and pressure analysis was performed in LabChart. Regression analysis was performed to show the relationship between airway pressures and airway flow before and after the BPB.

Results: A total of 34 patients were included in the study. Two patients declined participation and ten patients had incomplete data due to technical difficulties. 22 patients were included in the final analysis. Average age was 55.2 years and 54.5% were female. At baseline, the average negative airway pressure was 21.6 mmHg and the average airway flow rate from IS was 1091 mL/sec. After the BPB the average negative airway pressure decreased to 17 mmHg and the average airway flow rate decreased to 902 mL/sec. The percentage change of airway pressures and airway flow before and after BPB is presented in Figure 1-B.

Conclusion: This report demonstrates that patients´ effort is an important factor in generating enough negative airway pressure to get a desirable flow rate (number of balls being moved) on the IS. There is a linear relation between the negative airway pressure and airway flow as shown in Figure 1-B. In patients who receive interscalene BPB, it is important to evaluate diaphragmatic dysfunction, especially in patients with limited respiratory reserve (such as smokers, chronic obstructive pulmonary disease, interstitial lung disease). IS is a device that is inexpensive and easy to use. Assessment of diaphragmatic dysfunction after different approaches of BPB, as well as different volume of local anesthetic used, is recommended.

Reference:

1. Anesth Analg 1991; 72: 498–503.
2. Anesth Analg 1998 Jun;86(6):1239-44.
3. Anaesthesia 2001;56:352-6.
4. Diseases 2018 Feb 13;6(1):16.
5. Acta Anaesthesiol Scand 1992;36:53–7.

Figure 1-A: Incentive spirometry with pressure transducer

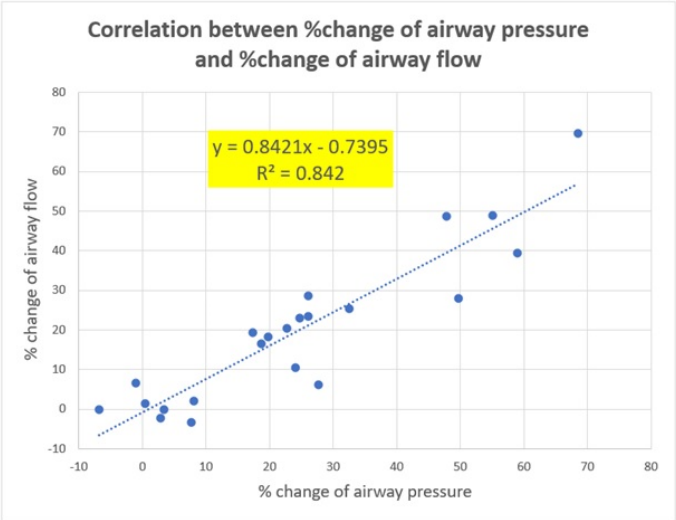

Figure 1-B: The relationship between airway pressure and flow before and after BPB