Incentive Spirometer could be used to detect diaphragmatic dysfunction but sedation could confound the results

Gudrun Maria Jonsdottir[1] MD MSc, Amy Jacob[2], Suthawan Anakmeteeprugsa[1] MD, Nousheen Mir[1] MD, kirk 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 common side effect of brachial plexus blocks (BPB), but a systematic assessment of the dysfunction is an uncommon practice. Spirometry, maximum inspiratory and expiratory pressures, chest x-rays, and ultrasound have been used to evaluate phrenic nerve dysfunction[1,2]. Pere *et* al. showed a clear decreased diaphragmatic motion after continued interscalene nerve block accompanied with restrictive changes observed on spirometry[1]. Incentive spirometer (IS) is an inexpensive and widely used device in the perioperative period but its use is effort dependent. Sedation is a common practice prior to peripheral nerve block placement and can affect patients´ respiratory effort when using IS. The objective of this study was to evaluate the effect of sedation on maximum inspiratory pressures generated on IS after sedation prior to and after BPB placement.

Methods: With IRB approval, all adult English-speaking patients without known neuromuscular disorder or diaphragm pathology, scheduled to undergo BPB for upper extremity surgery, were evaluated for recruitment. After informed consent patients were instructed on how to use an IS connected to a pressure transducer (Figure 1A). The IS has three balls and each ball presents flow volume, with three balls representing 1200 mL/sec, two balls representing 900 mL/sec, and one ball equal to 600 mL/sec flow[3]. A pulse oximeter was applied to the respective extremity. Real-time respiratory measurements were recorded prior to sedation, after sedation and after nerve block placement. Patient demographics, maximum negative inspiratory pressure, flows on IS and photoplethysmographic (PPG) amplitude, and peak area were collected. Data was entered into Excel® and pressure analysis were performed in LabChart (Figure 1B).

Results: Thirty-four patients were approached for participation from June to October 2022. Two patients declined participation, and five had incomplete data sets due to technical difficulties. A total of 27 patients were included in the analysis. Mean age was 55 years, and 52% were women. The average dose of sedation given intravenously was 89 mcg fentanyl and 1.9 mg midazolam. Average negative pressure generated prior to BPB placement was -20.4 mmHg (SD 8.4) with average 2.5 balls on IS. Significant reduction was seen after sedation was given, with average maximal negative pressures of -14.2 mmHg (SD 5.8) ($p<0.0001$) with average 2 balls on IS. Average time from sedation to IS evaluation was 2 minutes and 41 sec (SD 49 secs). Overtime, average maximal negative pressure improved to -16.4 (SD 7.9) with 2 balls on IS. Average time lapsed from BPB placement to post BPB IS evaluation was 25 min and 5 secs (SD 8 min and 14 secs). There was a significant decrease in negative inspiratory pressure before and after BPB ($p<0.00005$). An increase was seen in PPG amplitude from 4.2 to 8.2 and peak area from 1.4 to 2.4 before and after BPB placement, respectively.

Conclusion: Incentive spirometers could play a meaningful role in evaluating diaphragmatic dysfunction after BPB. However, their use is effort-dependent and our results showed that sedation had a significant effect on maximum negative pressure generated. In fact, sedation had a more profound effect than the BPB. It is unlikely that the BPB had not taken a full effect, as there was a consistent increase in both PPG amplitude and peak area indicating sympathectomy and successful BPB placement[4,5]. Improvement might be related to sedation wearing off over time. Pere *et* al. showed that premedication caused a significant decrease in respiratory muscle power (measured as maximal inspiratory and expiratory pressures)[1] so careful timing of a diaphragmatic dysfunction evaluation with IS is paramount in the setting of sedation.

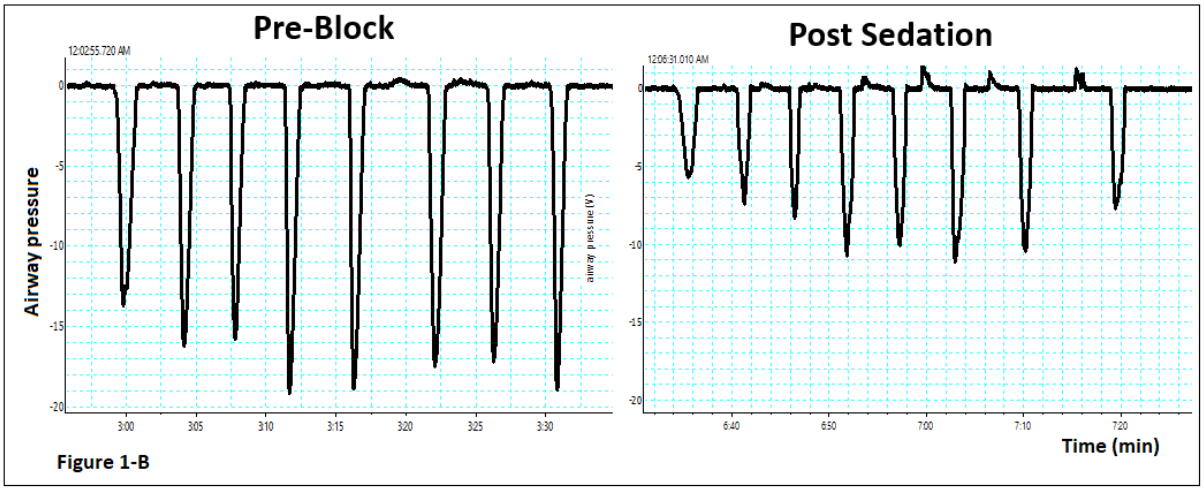

Figure 1 A IS connected to a pressure transducer. B Negative pressure waves from before and after sedation, respectively.

References:

1. Pere P, Pitkänen M, Rosenberg PH, Björkenheim J -M, Linden H, Salorinne Y, Tuominen M. Effect of continuous interscalene brachial plexus block on diaphragm motion and on ventilatory function. Acta Anaesthesiol Scand 1992;36:53–7.
2. Knoblanche GE. The incidence and aetiology of phrenic nerve blockade associated with supraclavicular brachial plexus block. Anaesth Intensive Care 1979;7:346–9.
3. Cairo JM. Mosby's respiratory care equipment. Elsevier Health Sciences, 2013.
4. Sebastiani A, Philippi L, Boehme S, Closhen D, Schmidtmann I, Scherhag A, Markstaller K, Engelhard K, Pestel G. Perfusion index and plethysmographic variability index in patients with interscalene nerve catheters. Can J Anesth 2012;59:1095–101.
5. Bergek C, Zdolsek JH, Hahn RG. Non-invasive blood haemoglobin and plethysmographic variability index during brachial plexus block. Br J Anaesth 2015;114:812–7. Available at: http://dx.doi.org/10.1093/bja/aeu484.