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Measuring Intra-abdominal Pressure during Spontaneous Breathing Trial: Does It Help?

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Authors' contributions

This work was carried out in collaboration between both authors. Authors MOE and MHS designed the study, wrote the protocol and wrote the first draft of the manuscript. Both authors managed the literature search and analyses of the study. Both authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Background: Respiratory system impairment may be caused by an increase of the intra-abdominal pressure (IAP).
Aim of Work: To assess the role of measuring intra-abdominal pressure in predicting successful weaning from mechanical ventilation.
Methods: 124 patients with acute respiratory failure ARF fulfilling the criteria for weaning were included. Each underwent a 1-hour spontaneous breathing trial (SBT). All clinical, respiratory parameters and mechanics were recorded. IAP was measured using Kron`s technique at the beginning and every 15 minutes till the end of SBT. The mean of IAP during SBT was calculated.
Results: Of 124 patients included in the study, 94 patients achieved successful SBT and extubation, while 31 patients needed re-intubation within 48 hours. Mean IAP was lower in patients that achieved successful SBT compared to patients who didn`t, 7.25 ± 2.28 vs 9.96 ± 2.6, p value < 0.001. Moreover, patients who needed re-intubation within 48 hours had higher mean IAP compared to patients who didn`t, 9.96 ± 1.4 vs 5.92 ± 1.17, P value < 0.001. The cut-off value of mean IAP that predict the need for re-intubation was 8.9 cm H_2O with sensitivity and specificity

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measuring 80% and 52% respectively. The Area Under the Curve (AUC) was 0.97. With multivariate regression analysis, mean IAP was an independent predictor of SBT failure (odds ratio (OR) 1.46, 95% confidence interval (CI) 1.62 to 1.839, p value 0.001). Using Spearman's rank correlation coefficient, it was found that mean IAP was positively correlated with auto ,positive end expiratory pressure, PEEP that measured at the beginning and at the end of SBT, and admission APACHE II score, with correlation coefficient measuring 0.515, 0.595, and 0.4 respectively.

Keywords: Intrabdominal pressure; weaning; spontaneous breathing trial.

1. INTRODUCTION

Weaning from mechanical ventilation remains a corner stone in the care of critically ill patients. Till now, there is still uncertainty about the best parameters that predict successful process [1].

Many respiratory system measurements are not affected by lung conditions alone and may be influenced by changes in the mechanics of the thoracic cage which in turn are affected by factors that affect intra-abdominal pressure. Many authors mentioned that respiratory system embarrassment may be caused by the intra-abdominal pressure elevation, and mechanical ventilation in patients with increased intra-abdominal pressure is affected by important alterations in respiratory mechanics and gas exchange [2,3,4].

Therefore, in addition to assessment of routine lung mechanics, accurate assessment of intra-abdominal pressure may be valuable in mechanically ventilated patients [5]. To date, the intravesical pressure detection is considered the method of choice for intra-abdominal pressure measurement [6-9].

1.1 Aim of the Study

To assess the role of measuring intra-abdominal pressure in predicting successful weaning from mechanical ventilation.

2. PATIENTS AND METHODS

This study was conducted as prospective study done on 124 adult patients admitted to the critical care medicine department of Cairo University with acute respiratory failure and mechanically ventilated for at least 48 hours in the period between March 2015 to December 2015. Informed written consent was taken from the patients` 1st degree relatives. All patients screened daily to assess eligibility for weaning from MV. Patients enrolled in the study were met all the following inclusion criteria [10]:

> Age was above 18 years, showed significant improvement of the underlying cause for MV, fully awake, had no or minimal need for vasoactive or sedative agents, showed adequate gas exchange, proved by a ratio of the partial pressure of arterial oxygen (PaO_2) to the fraction of inspired oxygen (FIO_2) more than 200 at a positive end-expiratory pressure (PEEP) of 5 cmH_2O while breathing an FiO_2 <0.5, had respiratory rate to tidal volume ratio (RVR) <105 breaths/min/L. [11,12].

All data including age, gender, cause and period of mechanical ventilation, length of hospital stay, and relevant investigations were obtained for all patients. Severity of critical illness was assessed by calculation of APACHE II score on the day of hospital admission. All patients that developed stridor or any signs of upper airway obstruction after extubation were excluded. Also patients in whom bladder pressure measurement was not feasible or inappropriate like urethral or bladder rupture were excluded.

Study patients were grouped as following:

> Group 1: included patients who had successful SBT and underwent extubation.
>
> Group 2: included patients who had failed SBT.

Patients in group 1 were further divided into group 1a: which included patients who didn't need re-intubation within 48 hours from extubation, and group 1b: included patients who needed re-intubation within 48 hours from extubation.

2.1 Study Protocol and Weaning Procedure

Once the inclusion criteria were met. Patients breathed through the ventilator circuit with flow triggering (2-5 L/min), with addition of continuous positive airway pressure between (CPAP) 0-5 cmH_2O and 10 cmH_2O of pressure support (PS) using commercially available ventilator (Puritan-Bennett 840).

2.2 Measurement of Respiratory Parameters

The static compliance of the respiratory system (Cst,rs) was measured in volume controlled mode after setting an inspiratory hold for 0.5 to 1.0 second. Then, Cst,rs was calculated by dividing the Vt by the difference between inspiratory plateau pressure and PEEP [13].

Auto-PEEP was measured by applying an end-expiratory pause for 0.5–2 s. initially and at the end of SBT (Follow up Autopeep: FU) The airway resistance R aw was estimated by dividing the difference of peak inspiratory pressure PIP and plateau pressure P plat measured in cm H_2O by airway flow measured in liters per second [14].

IAP measurement was done using Kron`s technique that involves disconnecting the patient's Foley catheter and instilling 50–100 ml of saline. After reconnection, the urinary drainage bag is clamped and a 16-gauge needle is then used to Y-connect a manometer. The symphysis pubis was taken as a reference line. All the measurements were converted to mm Hg [15].

Baseline IAP was measured before SBT (IAP1) and was measured at 15 minutes interval for 60 minutes (IAP2-IAP3-IAP4-IAP5). Then mean IAP was calculated.

Patients who tolerated the SBT were extubated and received oxygen by facemask. Successful extubation was defined as the ability to maintain spontaneous breathing for 48 hours after extubation. Following extubation, ventilatory support was reintroduced if the patient had the evidence of any of the following [16]: upper airway obstruction (stridor), hypoxemia (Sao_2 <90% for >5 minutes) with an FIO_2 >0.5, decompensated respiratory acidosis. Unless contraindicated, noninvasive positive pressure ventilation were tried before re-intubation.

For patients who showed poor tolerance to the SBT, the trial was aborted and ventilatory support was resumed. Any deterioration of vital signs or haemodyamics during the trial was considered failure of the trial.

2.3 Statistical Analysis

Data were statistically described in terms of mean ± standard deviation (± SD), median and range, or frequencies (number of cases) and percentages when appropriate. Comparison of numerical variables between the study groups was done using Student *t* test for independent samples. For comparing gender, Chi square (χ^2) test was performed. Correlation between various variables was done using Pearson moment correlation equation for linear relation in normally distributed variables and Spearman rank correlation equation for non-normal variables/ non-linear monotonic relation. *p* values less than 0.05 was considered statistically significant. All statistical calculations were done using computer program SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) release 15 for Microsoft Windows (2006).

3. RESULTS

Table 1 shows the baseline characteristics of patients studied. 124 patients (50.8% females and 49.2% males) with mean age 58.19 ± 7.31years were enrolled in the study. Of them, 94 patients achieved successful SBT and underwent extubation. Of these 94 patients who had successful SBT, 31 patients needed re-intubation within 48 hours.

Table 1 shows the baseline characteristics of patients studied. Shorter duration of mechanical ventilation, low admission APACHE II and lower rapid shallow breathing index(R/Vt) were significantly associated with successful SBT trials (5.27±1.17 vs 6.9±0.8 days, 21.8±3.2 vs 24.7±2.4 and 55.12±7.168 vs 71.27±5.44). As regards the lung mechanics, high baseline airway resistance, baseline and follow up auto PEEP were significantly associated with failed SBTs (5.59±1.5 vs 6.77±1.04, 3.82±1.12 vs 4.33± 0.88,and 2.4±1.29 vs 3.27±0.98, P value <0.001, 0.024, and <0.001 respectively). We found that higher mean IAP was associated with failure of SBTs (9.96±2.6 vs 7.25±2.28 P value <0.001) (Table 2).

Out of 94 patients who had successful SBT, 31 patients needed re-intubation within 48 hours. Need for re-intubation within 48 hours was higher in patient who had higher admission APACHE II score, higher airway resistance and auto PEEP at the beginning of SBT and higher auto PEEP at the end of SBT (follow up auto PEEP) (20.71±3.11 vs 24.1±2.23, 5.89±1.49 vs 4.97±1.35, 3.3±0.8 vs 4.87±0.88, and 3.58±0.84 vs 1.83±1.07, p value <0.001,0.005, <0.001< and <0.001 respectively) (Tables 3, 4).

Higher mean IAP were associated with failure of SBT and need for re-intubation with in 48 hours (9.96±2.26 vs 7.25±2.28 and 9.96±1.4 vs 5.91±1.17 respectively, p value < 0.001). Using the Receiver Operating Characteristics (ROC), the cut-off value of mean IAP that predict the need for re-intubation was 8.9 mm Hg with sensitivity and specificity measuring 80% and 52% respectively. The Area under the ROC Curve (AUC) was 0.97. Fig. 1 With multivariate regression analysis, mean IAP was an independent predictor of SBT failure (odds ratio (OR) 1.46, 95% confidence interval (CI) 1.62 to 1.839, p value 0.001).

Table 1. Baseline general characteristics of the study patients

All patients	Group 1: Successful SBT(94)	Group 2: Not successful SBT(30)	P value
Age	58.38±6.9	57.6±8.5	0.612
Duration of MV	5.27±1.17	6.9±2.4	<0.001
APACHE II	21.8±3.2	24.7±2.4	<0.001
Baseline FIO_2	41.28±3.51	41.67±2.39	0.572
Baseline SPO_2	95.15±2.46	96.37±2.64	0.022
Baseline R/Vt	55.12±7.168	71.27±5.44	<0.001
Baseline PO_2/FIO_2	265.77±15.5	265.33±17.8	0.89

Table 2. Lung mechanics and mean IAP of the study patients

All patients	Group 1: Successful SBT (94)	Group 2:Not successful SBT (30)	P value
Baseline static compliance	42.51±11.5	43.0±9.8	0.834
Baseline airway resistance	5.59±1.5	6.77±1.04	<0.001
Baseline auto PEEP	3.82±1.12	4.33±0.88	0.024
Follow up auto PEEP	2.4±1.29	3.27±0.98	0.069
Mean IAP	7.25±2.28	9.96±2.6	<0.001

Table 3. Baseline general characteristics of the study patients who need re-intubation

All patients	Group 1a: No Re-intubation (63)	Group 1 b: Re-intubation (31)	P value
Age	59.2±6.66	56.58±7.16	0.076
Duration of MV	5.11±1.11	5.58±1.26	0.068
APACHE II	20.7±3.11	24.1±2.34	<0.001
Baseline FIO_2	41.59±3.68	40.0±3.09	0.223
Baseline SPO_2	95.46±2.29	94.52±2.72	0.081
Baseline R/Vt	55.7±7.0	53.94±7.39	0.264
Baseline PO_2/FIO_2	267.02±15.47	263.0±15.53	0.268

Table 4. Lung mechanics and mean IAP of the study patients who need re-intubation

All patients	Group 1a: No Re-intubation (63)	Group 1b: Re-intubation (31)	P value
Baseline static compliance	43.24±11.24	41.03±12.08	0.385
Baseline airway resistance	5.89±1.49	4.97±1.35	0.005
Baseline auto PEEP	3.3±0.8	4.87±0.88	<0.001
Follow up auto PEEP	3.58±0.84	1.83±1.07	<0.001
IAP	5.92±1.17	9.96±1.4	<0.001

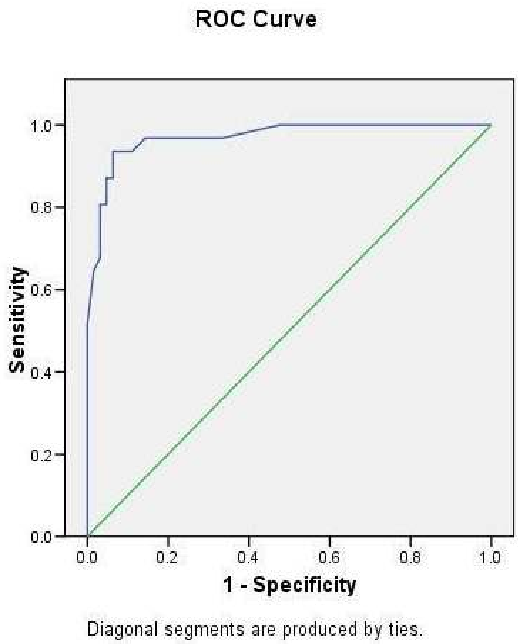

Fig. 1. Roc curve for mean IAP as a predictor for need of re-intubation

Using Spearman`s ratio, it was found that mean IAP was positively correlated with baseline auto PEEP, follow up auto PEEP, and APACHE II sores, with correlation coefficient measuring 0.515, 0.595, and 0.4 and highly significant p Value < 0.001.

4. DISCUSSION

IAP is a vital physiological parameter in critically ill patients, and the value of measuring it is becoming more established in many ICUs. Moreover, many studies have revealed the drawbacks of increased IAP on respiratory function of these patients [17,18].

This study proved that measuring IAP in mechanically ventilated patients would help in prediction of success of SBT and weaning from mechanical ventilation. As our results indicate that increased IAP strongly predicts failure of SBT and need for re-intubation within 48 hours of extubation. As shown in our results: although all of the study patients had normal IAP, still patients who had higher IAP had higher incidence of failed SBT. These findings can be explained by strong positive correlation between IAP and auto PEEP that was measured at the beginning and at the end of SBT in the study. Excessive auto-PEEP leads to increased intrathoracic pressure, which is transmitted to the abdominal compartment and increased IAP, which in turn affect lung compliance and reduces total lung capacity and residual volume [19,20]. This possible mechanism of auto-PEEP elevation may have therapeutic impact by targeting management to lower the intra-abdominal pressure.

Dwight Matthew, et al mentioned the same idea in their case report. They reported that the excessive auto-PEEP led to increased intrathoracic pressure which resulted in intra-abdominal hypertension (IAH) with subsequent abdominal compartment syndrome [21]. Also, Torquato Jamili Anbar, et al. [2] reported the association between lung mechanics and IAP as they found that increasing Positive-End Expiratory Pressure from zero to 10 cm H_2O and adding 5 kg to the belly increased both intra-abdominal and plateau pressure.

Our study also showed that the short duration of mechanical ventilation and low admission APACHE II score were predictive of weaning success. In concordance to these results, Schönhofer B, et al. Yao-kuang Wu, et al. and Meade et al. [22,23,24] reported that APACHE II can be useful to predict weaning outcome in mechanically ventilated patients.

On the contrary, Annalisa Carlucci, et al. [25] found that SAPS II score was higher in successful weaning group although this finding was statistically insignificant. Their study was done on 30 tracheotomised ventilator-dependent patients. All of their patients were ventilitated for more than 30 days. This peculiar study group may explain the difference between our and their results.

Our study also proved that airway resistance and auto PEEP that was measured at the beginning and at the end of the SBT were predictive of the success of the trial. Again, Annalisa Carlucci, et al. [10] reported the trend of lower airway resistance and auto PEEP in their successful weaning group but they failed to prove any statistical value of this finding. Their small sample size, 30 patients, compared to our sample size, 124 patients may explain this contradiction.

Hence, we recommend that all mechanically ventilated patients should have intra-abdominal pressure monitoring in addition to their regular lung mechanics monitoring.

5. STUDY LIMITATIONS

In addition to relatively small sample size, we didn't measure lung volumes and capacities to prove our postulation that increase IAP may decrease them which in turn may lead to weaning failure. Also, we took intermittent readings for IAP for only one hour during SBT. We think that continuous IAP monitoring during the whole weaning process will be more valuable and informative. As well as, we didn't study the relation between IAP and other prognostic indicators like mortality or ventilator associated pneumonia.

6. CONCLUSION

Intra-abdominal pressure is positively correlated with auto PEEP that was measured at the beginning and at the end of SBT. High IAP predicts failure of SBT and need for re-intubation within 48 hours. Prolonged mechanical ventilation and high admission APACHE II predict weaning failure as well.

ETHICAL APPROVAL AND CONSENT TO PARTICIPATE

The study has been approved by the ethics committee of Cairo University and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Informed written consent after explaining the details of the study and the possibility of publications were obtained and signed from the patients ` 1st degree relatives.

AVAILABILITY OF SUPPORTING DATA

All the data collected and statistical data are available.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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