**Supplementary Digital Content**

Evaluation of the Augmented Infant Resuscitator (AIR): a monitoring device for neonatal bag-valve-mask resuscitation

Desmond J. Bennett1; Taiga Itagaki1,2; Christopher T. Chenelle1; Robert M. Kacmarek1,2

1. Department of Respiratory Care, Massachusetts General Hospital, Boston, MA, United States of America
2. Department of Anesthesia, Critical Care and Pain Medicine, Massachusetts General Hospital, Harvard Medical School, Boston, MA, United States of America

*Bag-Squeezer Validation*

**Background**

The bag-squeezer is a device we created in order to ensure accuracy and consistency of delivered breaths when using a ventilation bag. Manually squeezing a ventilation bag does not ensure a consistent tidal volume or respiratory rate. The device we created was designed to squeeze a 220-ml ventilation bag (161-ml max tidal volume) (Laerdal Medical, Stavanger, Norway) at settings of our choosing. It has two simple knobs: the rate knob, which has three settings of 40, 50, and 60 breaths per minute, and the tidal volume knob, which has a range of 6 – 48 ml.

**Methods**

 The bag-squeezer was connected to the ASL 5000 breathing simulator, which was used to evaluate the accuracy of the bag-squeezer. For each model, the bag-squeezer ventilated the ASL 5000 for five minutes, and data was analyzed.

**Results**

Data from the bag-squeezer can be found in Table S1.

**Table S1.** Bag-Squeezer data for each model.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Model | Insp VT (ml) | Exp VT(ml) | PEEP (cmH2O) | Respiratory Rate (bpm) |
| Model 1 (n=300) Desired Observed | 12.0012.276 ±0.187 | 12.0012.277 ±0.180 | 0.019 ±0.007 | 60.0060.130 ±0.168 |
| Model 2 (n=250) Desired Observed | 24.0024.756 ±0.117 | 24.0024.756 ±0.109 | 0.157 ± 0.21 | 50.0050.111 ±0.145 |
| Model 3 (n=200) Desired Observed | 36.0036.349 ±0.124 | 36.0036.343 ±0.155 | 0.146 ±0.021 | 40.0040.087 ± 0.090 |
| Key– Insp VT: inspiratory tidal volume; Exp VT: expiratory tidal volume; PEEP: positive end-expiratory pressure; n: number of breaths analyzed. |

**Conclusions**

 The sensitivity of the tidal volume knob was less than preferred, which is why tidal volumes varied slightly from the desired value. However, we considered the slight variation negligible for the purposes of testing the AIR device. PEEP was low for all three models, and respiratory rate was accurate and consistent.

*Comparing Breath Parameters*

**Table S2.** Breath parameters from the ASL 5000 with AIR inline and without AIR inline.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  Model | I Time(s) | E Time (s) | Insp VT (mL) | Exp VT (mL) | Ppeak(cmH2O) | Pmean (cmH2O) | Peak Flow (L/min) | PEEP (cmH2O) | Respiratory Rate (bpm) |
|  |  |  |  |  |  |  |  |  |  |
| Model 1 (n=300) AIR inline No AIR Difference (%) | 0.31±0.000.31±0.000.00\* | 0.69±0.000.69±0.000.00 | 12.08±0.0312.13±0.03-0.41\* | 12.08±0.0412.12±0.03-0.33\* | 5.15±0.025.11±0.030.78\* | 1.97±0.021.92±0.022.60\* | 5.12±0.045.03±0.041.79\* | 0.67±0.020.62±0.028.06\* | 60.02±0.1660.02±0.180.00 |
|  |  |  |  |  |  |  |  |  |  |
| Model 2 (n=250) AIR inline No AIR Difference (%) | 0.41±0.000.41±0.000.00\* | 0.79±0.000.79±0.000.00 | 24.17±0.0424.29±0.04-0.49\* | 24.17±0.0424.29±0.04-0.49\* | 7.89±0.027.90±0.02-0.13 | 3.11±0.013.07±0.011.30\* | 6.03±0.046.11±0.05-1.31\* | 0.67±0.010.68±0.02-1.47\* | 50.01±0.1050.02±0.12-0.02 |
|  |  |  |  |  |  |  |  |  |  |
| Model 3 (n=200) AIR inline No AIR Difference (%) | 0.49±0.000.49±0.000.00 | 1.01±0.001.01±0.000.00\* | 35.79±0.0435.83±0.06-0.11\* | 35.79±0.0435.83±0.06-0.11\* | 8.19±0.028.09±0.021.24\* | 3.10±0.012.98±0.014.03\* | 7.34±0.047.59±0.03-3.29\* | 0.54±0.010.50±0.028.00\* | 40.02±0.0640.01±0.030.02\* |
| Key– I Time: inspiratory time; E Time: expiratory time; Insp VT: inspiratory tidal volume; Exp VT: expiratory tidal volume; Ppeak: peak pressure; Pmean: mean pressure; PEEP: positive end-expiratory pressure; n: number of breaths analyzed.\*The difference was statistically significant at p < 0.05. Significant differences with % difference of 0.00 are due to rounding. No comparisons reached a greater than 10% difference. |

*Results from Altered Rate Scenario*

**Table S3.** Altered Rate Scenario, All Models

|  |  |
| --- | --- |
|  | Ventilator |
| Model andIndicator | # Correct | # Total | % Correct |
| Model 1 Rate Indicator | 32\* | 95 | 33.7 |
| Model 2Rate Indicator | 95 | 95 | 100.0 |
| Model 3Rate Indicator | 75‡ | 95 | 78.9 |
| \* | Incorrectly read rate “too high” or “too low” during normal rate: 31 cases; read “too high” or “OK” during low rate: 10 cases; read “too low” at a high rate: 14 cases; displayed no rate light for 1 case. The AIR couldn’t detect flow during 7 cases and automatically shut off; counted as incorrect. |
| ‡ | Incorrectly read “too low” at a high rate: 15 cases; read rate “OK” during high rate: 5 cases. |