D-32084-2011

Volume Guarantee

Initiation and ongoing clinical management of an infant supported by Volume Guarantee – A Case Study

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The patient is a premature female infant born at 25 4/7 weeks, weighing 452 grams, following premature rupture of membranes at a community hospital. She was supported briefly in the delivery room with CPAP following surfactant administration, and was transferred to a level IV NICU for further care on the second day of life. The infant arrived at the hospital with the neonatal transport team on CPAP with a pressure of 8 cm H_2O and a set FiO_2 of 0.7. The infant was in distress and presented with the following: nasal flaring, intercostal and substernal retractions, and occasional apneic episodes responding to intermittent tactile stimulation. The chest x-ray showed diffuse bilateral infiltrates and profound hypoinflation, consistent with Respiratory Distress Syndrome (RDS).

Due to the patient's deteriorating respiratory status on high CPAP settings, Non-Invasive Ventilation (NIV) was initiated using the Dräger Babylog VN500.

Initial Settings

Application Mode	NIV
Mode	PC-CMV
PIP	20 cm H_2O
PEEP	6 cm H_2O
Respiratory Rate	20/min
Ti	0.4 s
FiO_2	0.6

Initial arterial blood gas via Umbilical Artery Catheter

pH	7.28
$PaCO_2$	55 mmHG
PaO_2	55 mmHG
HCO_3	19 mmHG

NIV resulted in reduced work of breathing and avoided intubation for this patient. The patient was initially asynchronous with the non-invasive PC-CMV breaths, so the respiratory rate (RR) was adjusted to match every other spontaneous effort being made by the patient (Figure 1).

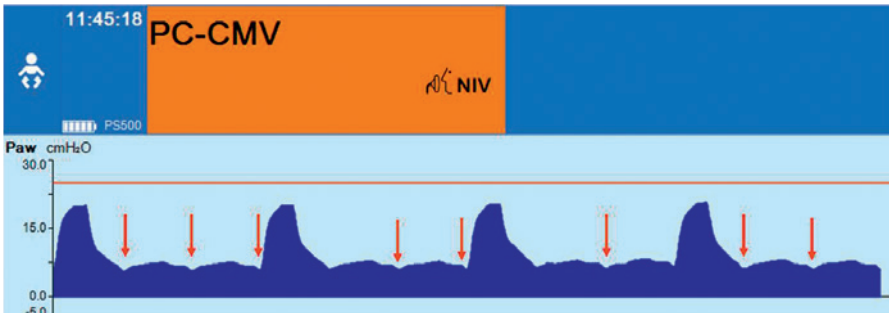

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Figure 1: Graphical representation of airway pressure in the patient during NIV with the Babylog VN500

The red arrows in Figure 1 indicate small depressions in the baseline pressure where the patient is making an inspiratory effort. Adjusting the rate to provide fully supported breaths on every other spontaneous effort was useful for improving synchrony in this patient.

The patient failed NIV after 10 hours due to apnea, desaturations, and bradycardia. The chest x-ray (Figure 2) after intubation revealed diffuse bilateral infiltrates consistent with RDS. The patient was given 2 mL/kg Curosurf® for poor compliance (0.5 mL/cm H_2O), refractory hypoxemia, and radiographic evidence of pulmonary atelectasis.

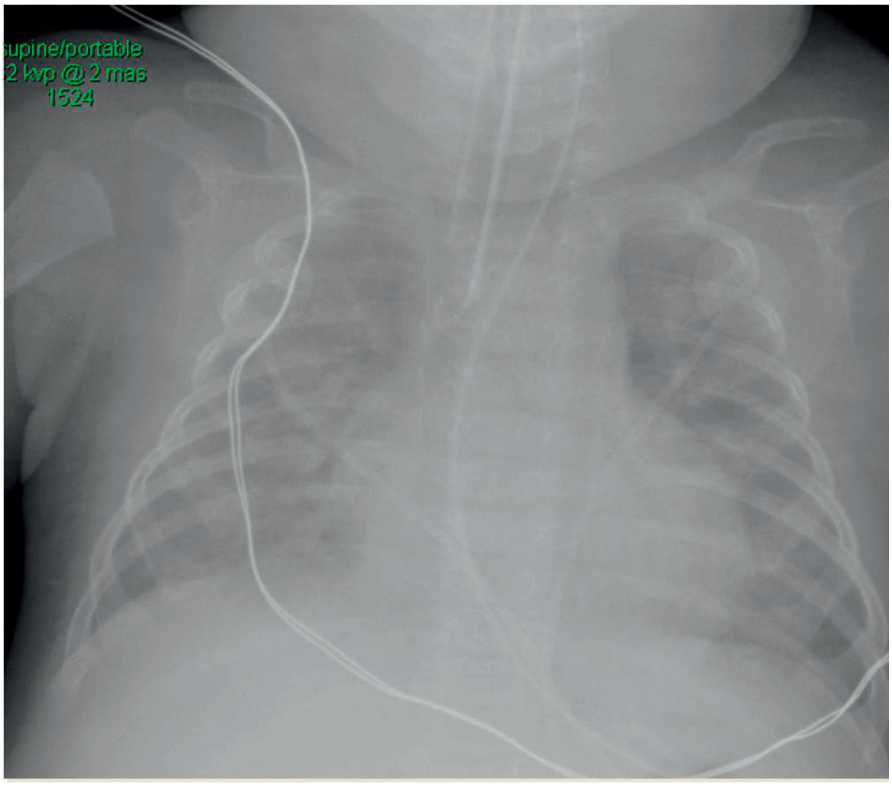

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Figure 2: X-ray after intubation

The application mode was changed to “tube” for invasive ventilation. The physician ordered PC-AC with Volume Guarantee (VG) with the following settings: tidal volume (VT) of 4 mL/kg, PEEP of 8 cm H_2O, an inspiratory time (Ti) of 0.3 s, RR 50 /min. The patient was spontaneously assisting all breaths and was breathing at a rate of 70/min. The transcutaneous CO_2 levels were 75 mmHg and these values correlated well with the arterial CO_2 levels observed with the last blood gas on nasal CPAP. Upon the physician's request, the Respiratory Therapist (RT) increased the VT to 5 mL/kg to account for the instrumental deadspace of the flow sensor and ET tube. The respiratory rate and CO_2 levels decreased in response to this change and the patient appeared comfortable.

Following this change, an audible ET tube leak could be heard. The ventilator was registering a 50–60 percent leak and an alarm on the ventilator began reading “VT low”. This problem was remedied by changing the Pmax setting from 25 to 30 cm H_2O in order to provide enough pressure to allow the tidal volume to be delivered.

Twenty-four hours later, the patient’s lung mechanics improved as reflected by lower Peak Inspiratory Pressure (PIP) values. However, the bedside Registered Nurse (RN) expressed concerns that the patient appeared tachypneic and had low PIP values. The bedside RT assured the nurse that this was related to the nursing care and usually the PIP values returned to normal after care was rendered. The RT presented a trend of the pressures and volumes (Figure 3) to the RN. She was then assured that this was a normal function of the ventilator and may be appropriate so that the patient isn’t receiving too much pressure and volume during periods of anxiety.

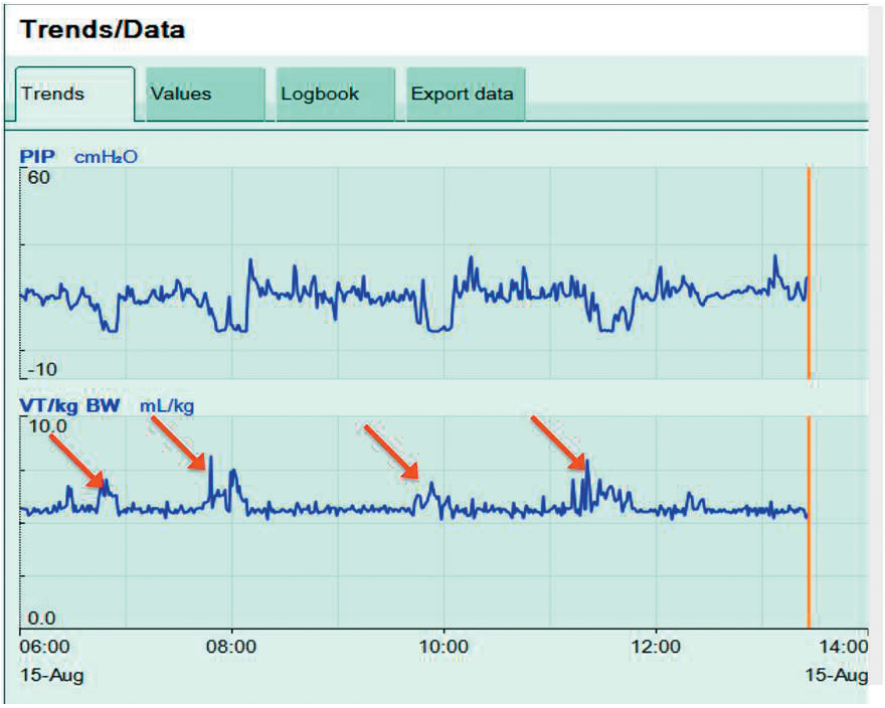

Figure 3: Trend of Tidal volume and airway pressure

The trending of pressure and volume show reduced inspiratory pressures due to increased volumes during periods of nursing care (red arrows). The patient's efforts are reduced after nursing care, resulting in smaller volumes and higher PIP values.

A month later, the infant was still supported with the Babylog VN500 in the PC-AC mode with Volume Guarantee activated. The infant gradually started showing signs of increased work of breathing on the ventilator and increased FiO_2 requirement following upsizing of the ET tube.

Settings

Application Mode	Tube
Mode	PC-AC with VG
PIP	7 cm H_2O
Vt	14.4 mL (set) 17.5 mL (measured)
PEEP	6 cm H_2O
Respiratory Rate	20/min
Ti	0.30 s
FiO_2	0.29

Venous Blood Gas

pH	7.23
$PaCO_2$	68 mmHG
PaO_2	23 mmHG
HCO_3	29 mmHG

Airway graphics revealed consistently low PIP values with tidal volumes greater than that set on the ventilator (Figure 4A). The chest x-ray showed low lung volumes with increasing atelectasis and air bronchograms (Figure 4B) from the previous exam. The patient developed retractions, nasal flaring, and SpO_2 78-89 percent. Breath sounds were reduced in the bases with fine inspiratory crackles throughout.

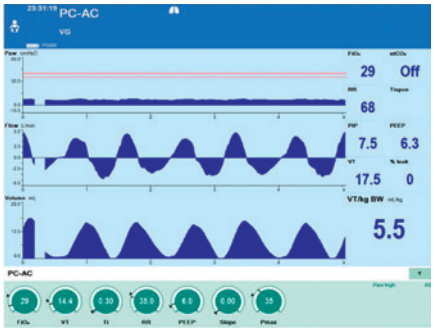

Figure 4A: Inadequate support during PC-AC

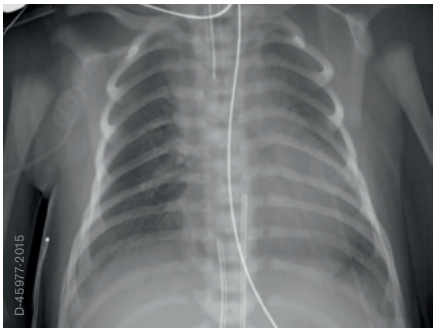

Figure 4B: Strong infiltration constant with atelectasis

Based on the clinical deterioration, the RT chose to assess the appropriateness of the tidal volume setting. The attending neonatologist wanted to place the patient in PC-AC without Volume Guarantee, so that the patient could get a higher level of support. During this time, the NICU team discovered that the dose-calculated weight in the ventilator hadn't been updated in over a month. When the new weight was entered, it became obvious that the patient was only receiving a tidal volume ~3.5 mL/kg. This prompted the team to increase the set tidal volume targeted from 14 to 19 mL. This resulted in an immediate reduction in the observed high levels of work of breathing and increased in PIP values (Figure 5A) as well as radiographic improvement in lung inflation (Figure 5B).

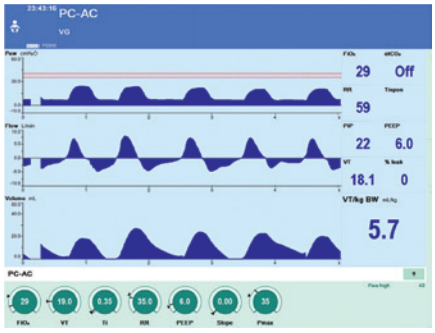

Figure 5A: Airway graphic following setting change

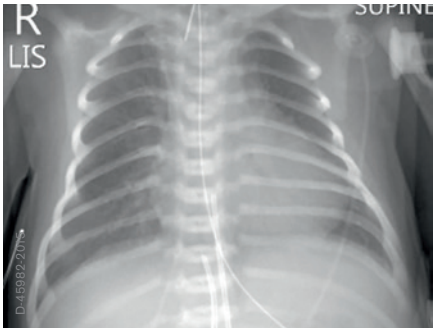

Figure 5B: X-ray following setting change

A week later the PIP values were again reduced to only 1 cm H_2O above the PEEP level during PC-AC with Volume Guarentee. However, with the exception of this time, the patient had normal breathing and acceptable gas exchange. Based on this, the patient was extubated to non-invasive CPAP. Subsequently, five days later, the patient was transferred home utilizing oxygen therapy at 0.5 L/min via nasal cannula.

Robert DiBlasi RRT-NPS, FAARC is Manager of Clinical Diagnostics and Research in the Respiratory Care Department at the Seattle Children's. Rob is also a Principle Investigator for the Center for Developmental Therapeutics at the Seattle Children's Hospital Research Institute. His research interests include: neonatal pulmonary mechanics monitoring, patient/ventilator interaction, ventilator induced lung injury, neonatal lung protective strategies, mechanical ventilator performance, and aerosolization of respiratory medications. Rob is an inventor for multiple life support devices designed for use in resource limited settings, receiving much of the funding for implementing these devices in the clinical setting from the Bill and Melinda Gates Foundation. He has authored 25 peer reviewed papers, 12 textbook chapters on neonatal and pediatric mechanical ventilation, and co-editor for the 4th edition of Perinatal/Pediatric Respiratory Care Textbook. He also serves on the Editorial Board for RESPIRATORY CARE journal. He is also a fellow of the American Association for Respiratory Care.

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CORPORATE HEADQUARTERS
Drägerwerk AG & Co. KGaA
Moislinger Allee 53–55
23558 Lübeck, Germany

www.draeger.com

Manufacturer:
Drägerwerk AG & Co. KGaA
Moislinger Allee 53–55
23558 Lübeck, Germany

REGION EUROPE CENTRAL AND EUROPE NORTH
Drägerwerk AG & Co. KGaA
Moislinger Allee 53–55
23558 Lübeck, Germany
Tel +49 451 882 0
Fax +49 451 882 2080
info@draeger.com

REGION EUROPE SOUTH
Dräger Médical S.A.S.
Parc de Haute Technologie
d'Antony 2
25, rue Georges Besse
92182 Antony Cedex, France
Tel +33 1 46 11 56 00
Fax +33 1 40 96 97 20
dlmfr-contact@draeger.com

REGION MIDDLE EAST, AFRICA
Drägerwerk AG & Co. KGaA
Branch Office
P.O. Box 505108
Dubai, United Arab Emirates
Tel +971 4 4294 600
Fax +971 4 4294 699
contactuae@draeger.com

REGION ASIA / PACIFIC
Draeger Medical
South East Asia Pte Ltd.
25 International Business Park
#04-27/29 German Centre
Singapore 609916, Singapore
Tel +65 6572 4388
Fax +65 6572 4399
asia.pacific@draeger.com

REGION NORTH AMERICA
Draeger Medical, Inc.
3135 Quarry Road
Telford, PA 18969-1042, USA
Tel +1 215 721 5400
Toll-free +1 800 437 2437
Fax +1 215 723 5935
info.usa@draeger.com

REGION CENTRAL AND SOUTH AMERICA
Dräger Panama Comercial
S. de R.L.
Complejo Business Park,
V tower, 10th floor
Panama City
Tel +507 377 9100
Fax +507 377 9130
contactcsa@draeger.com

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