



Medstar LPV Compliance Report

May 2019

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Overview

Acute respiratory distress syndrome (ARDS) represent a major global public health problem. Almost one-quarter of patients requiring mechanical ventilation (MV) develop ARDS, conferring a 40% in-hospital mortality rate. Unequivocal evidence shows that lung-protective ventilation (LPV), aimed at mitigating ventilator-associated lung injury (VALI), reduces mortality in patients with ARDS. The emergency department (ED), where over 200,000 patients are mechanically ventilated annually in the U.S., may be an important venue for providing LPV to improve ARDS outcomes. Experimental data shows that ventilator-associated lung injury (VALI) can occur shortly after initiation of MV and ED lengths of stay are often more than enough to begin the process of VALI leading to ARDS. Yet, 40% of patients with ARDS or at high risk of ARDS are not identified and 35% do not receive LPV. Under-recognition of patients with ARDS in the ED is thought to be a major reason for inappropriate treatment.

Clinical encounter data of adult patients were extracted from the MedStar Health Cerner EHR repositories across seven MedStar hospitals. Control cohort consists of 30,196 ED/ICU encounters from 1/1/2015-8/8/2018 and 1017 ARDS case encounters from 1/1/2013-9/8/2018. As a precursor to the development of a predictive model towards early detection and prediction to guide improved LPV management of ED patients who have, or are at high risk of developing, ARDS, a baseline estimate of existing LPV compliance in the presence of ARDS at MedStar Health is needed. This document describes the methodology used to extract and process feature data, create patient cohorts and compute different compliance levels of LPV at MedStar Health.

Challenges

- Missing Height and / or Weight (Sourced from structured values of the ER Triage Notes): Not all encounters have a recorded height and/or weight; where the height is used to calculate the ideal body weight and weight is used in lieu of no reported height. This value is then used as the basis of calculating the threshold for LPV compliance of Tidal Volume values.
- Data Availability during the care in the Emergency Department:
 - Very few Tidal Volume events recorded from the Respiratory Event Sources file while in the Emergency Department.
 - ED Triage Notes contains textual data for additional physiological data that can be used in addition to the structured data events. (i.e. SpO2), in conjunction with Respiratory related triage elements (Oxygen Delivery Device)
 - Alternatives to pull data from ER Triage Note structured Fields. Structured Tidal Volume Data Availability in the Emergency Department; will extract some values from free text notes - **WIP**

Unstructured Data

Emergency Medicine unstructured note counts

Metric	Total Count	Note Type
ALL	126,721	ED Note-Nursing
ALL	16,390	ED Note-Clinician
“tidal”	295	ED Note-Nursing
“tidal”	222	ED Note-Clinician
“intubation”	1849	ED Note-Nursing
“intubation”	1706	ED Note-Clinician

Variable/Feature Definitions

Tidal Volume

Tidal Volume according to the criteria below. Tidal Volume Set used when available. Otherwise use Tidal Volume, Exhaled.

“For patients on volume control mode, we should definitely go by the set tidal volume. however, there are modes in which you don’t set the tidal volume, you set a pressure to apply and then it is up to the provider to ensure that the tidal volume received is appropriate for ARDS. so you will probably come across cases in which there is no set tidal volume, and in those, we will have to use the exhaled tidal volume.” - Amit 22, April 2019

Tidal Volume codes

Code	# Enc.	# Enc. Event < Admit TS	Min	Max	Avg	Med	Comment
Respiratory Events							

Tidal Volume Set	9671	192	-500	60040	454	450	
Tidal Volume, Exhaled	9851	193	0	8701	481	471	
BiPAP/CPA P Exhaled Tidal Volume	6630	273	10.0	2000	482	455	* Should possibly exclude
Tidal Volume Set (L)	525	4	0	783	167	0.55	Value multiplied by 1000 to convert to mL
Blood Gas Events							
BG VT	4273	715	10	82077	2726	500	Filter out < 100 and > 3000
Tidal Volume	1803	8	-380	1941	435	409	Filter out < 100 and > 3000
Free Text Recordings of Tidal Volume							
TBD							

PaO2/FIO2 Ratio Imputation

Calculate PaO2/FIO2 Ratio using:

- PaO2 sourced from the pO2 Respiratory Event
- FIO2 sourced from the FIO2 Respiratory Event (values <0 and > 100 excluded)

SpO2/FIO2 Ratio Imputation

Calculate SpO2/FIO2 Ratio using :

- SpO2 sourced from the SpO2 Vital Sign Event (values < 70 and > 100 excluded)
- FIO2 sourced from the FIO2 Respiratory Event (values <0 and > 100 excluded)

PaO2,SpO2,FiO2 (unfiltered) metrics

	FIO2	PaO2	SpO2
--	------	------	------

Min	0	15.0	-98.0
Max	509.0	637	999.0
Avg	58.26	192	182.8
Median	51.7	157.2	74.0

PaO2,SpO2,FiO2 (filtered) metrics

	FIO2	PaO2	SpO2
Min	0	15.0	70
Max	100.0	637	100.0
Avg	53.70	192	85
Median	51.3	157.2	85.0

PaCO2

PaCO2 sources from lab results with the code = 'pCO2 Art'

Metric	PaCO2
Min	10.0
Max	211.0
Avg	43.48
Median	40.0

Event Definitions

Descriptions of events used within the compliance report.

ARDS Onset Event

The earliest calculated observation of:

- With recorded FIO2
 - PaO2/FIO2 ratio < 300

- SpO2/FiO2 <315
- Without a recorded
 - SpO2 < 90 in absence of FIO2
 - PaO2 < 60 in absence of PaO2
- Or PaCO2 > 45

PaO2/FiO2 and SpO2/FiO2 imputed as described above.

Cohort Descriptions

The base inclusion criteria into the study cohorts are:

- The patient passed through an Emergency Medicine care setting during the overall encounter
- The patient has a reported Height (to calculate Ideal Body Weight) or in absence of height a reported Weight.
- The patient has at least one recorded tidal volume event.

This baseline inclusion criteria filters down the original 30469 encounters to 26353:

Starting N = 30469, filtered to ED encounter: N = 28900, filtered by reported height/weight: N = 26353

ARDS Cohort

Patient encounter meets the baseline inclusion criteria and has a coded ARDS code per the [Appendix: ARDS Diagnosis ICD Codes used to flag ARDS Cohort](#). The number of encounters in/out of the ARDS Cohort is described in Table 1. The frequency of these codes across encounters is [Appendix - Frequency of Encounters / Code](#)

Table 1 - ARDS Encounter Count

Label	Encounter Count	Percent
Total	26353	100
ARDS = YES	7908	25.95
ARDS = NO	18445	60.54

Bime ARDS Cohort

The Bime Criteria includes encounters that have all of the following:

- Has a coded diagnosis for the encounter from [Appendix - Bime Diagnosis Inclusion](#).
- Does not have a coded diagnosis from [Bime Diagnosis Exclusion](#).
- Has a coded Procedure from [Bime Procedure Inclusion](#).

Table 2 - Bime ARDS Cohort Counts

Bime Yes/No	Encounter Count	Percent
Total	26353	100
Yes	3826	12.56
No	22527	73.93

Table - Cohort Length of Stay Metrics * Need to remove outliers

Cohort	Avg. LOS ED Hrs	Median LOS ED Hrs
Total	8.655	5.23
Bime	7.48	4.6
ARDS	8.66	5.33

Intubation Cohort

Patients having an intubation as sourced from procedure codes: [Appendix - Intubation Procedure Codes](#) or observation codes: [Appendix: Intubation Observation Codes](#).

Intubation Summary within the ARDS Cohort

Encounter Count	Percent	Intubation
6761	85.5	Yes
1147	14.5	No
9293	100.0	All

Intubation Summary for the Bime Cohort

Encounter Count	Percent	Intubation
3826	100	Yes
0	0	No
3826	100	All

Compliance Cohorts

Cohort Name	N	Description
ARDS Compliance Cohort	6761	The intersection of the ARDS Cohort and Intubation Cohort
Bime Compliance Cohort	3826	The intersection of the Bime ARDS Cohort and Intubation Cohort,

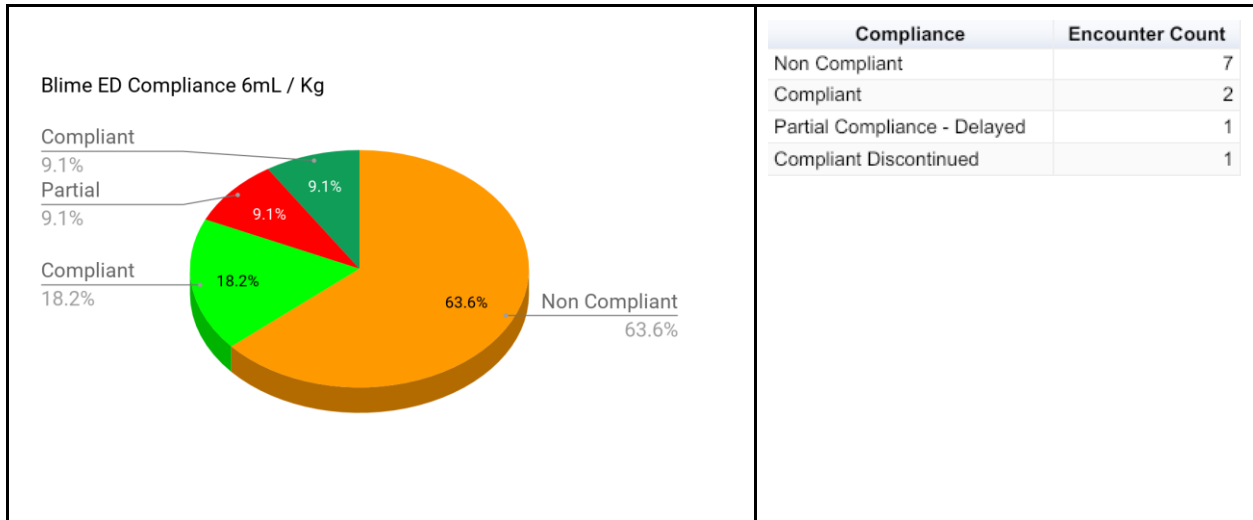
LPV Compliance Report

- Complaint Tidal Volume Event (CTV)- A Tidal Volume value $\leq 6\text{ML/KG}$
- ED Compliance Report Period (CRP) - The time range from the ARDS onset time through the remainder of the ED stay. If no Tidal Volume entries present during this initial time period the time range is extended to include the first 6 hrs of inpatient care or first Tidal Volume reading; whichever is first.
- Inpatient Compliance Report Period - The time range from inpatient admission to discharge.

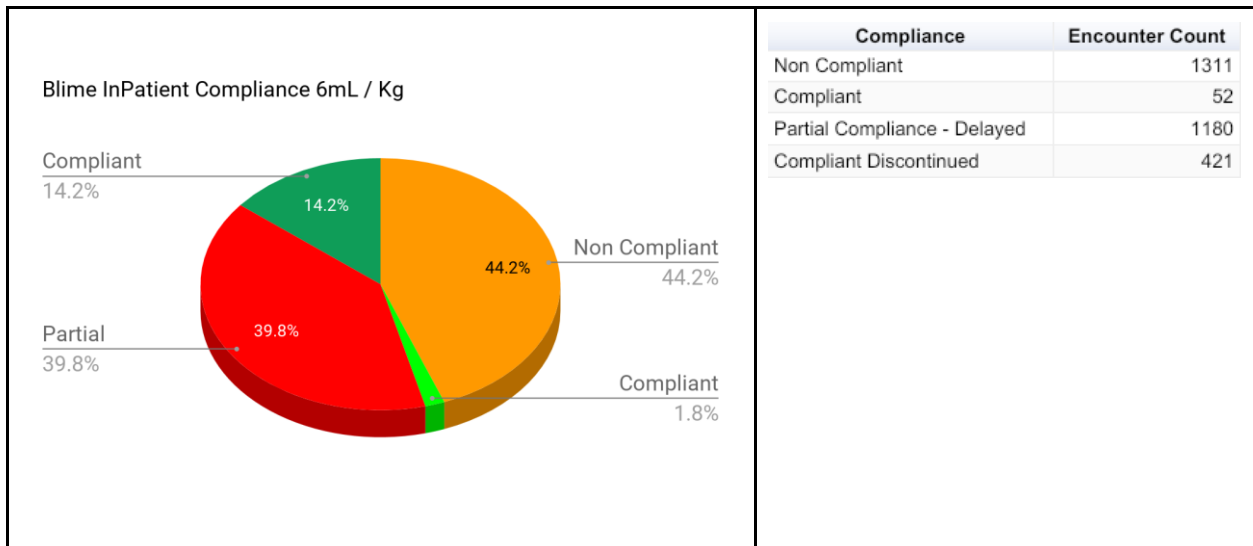
The following compliance groups are used:

1. Non-Compliant: ARDS is present and no Tidal Volume events meeting CTV criteria are present during the Compliance Report Period .
2. Compliant: All recorded Tidal Volume events meet CTV criteria throughout the Compliance Report Period
3. Compliant - Discontinued: Initial Tidal volume events meet CTV criteria and are then discontinued before the end of the Compliance Report Period
4. Partial Compliance - Delayed: ARDS + LPV Delayed (>60mins) : Tidal Volume events that do not meet CTV criteria with following events that do meet CTV criteria within the Compliance Report Period

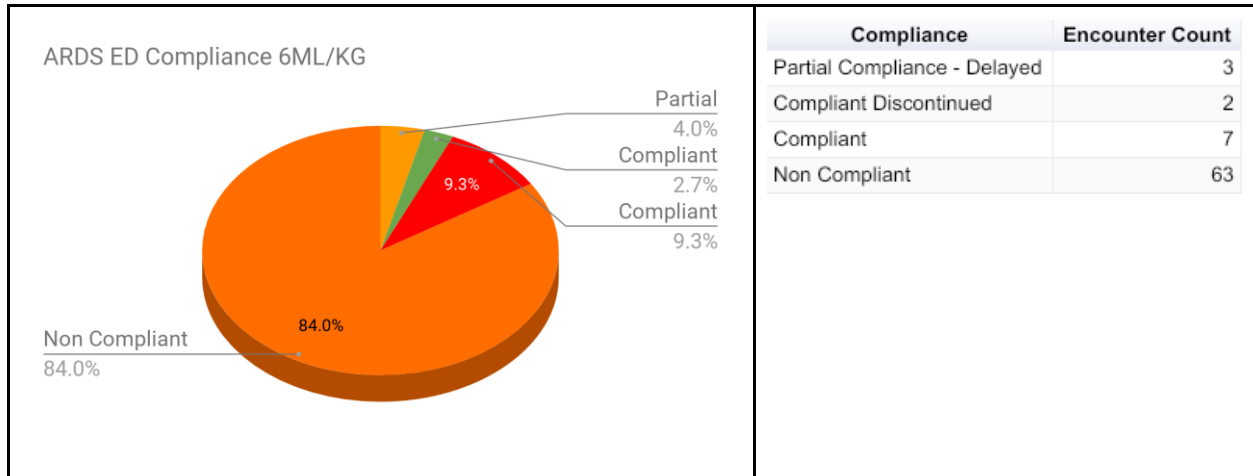
Bime ED Compliance Rate <= 6mL/KG IBW



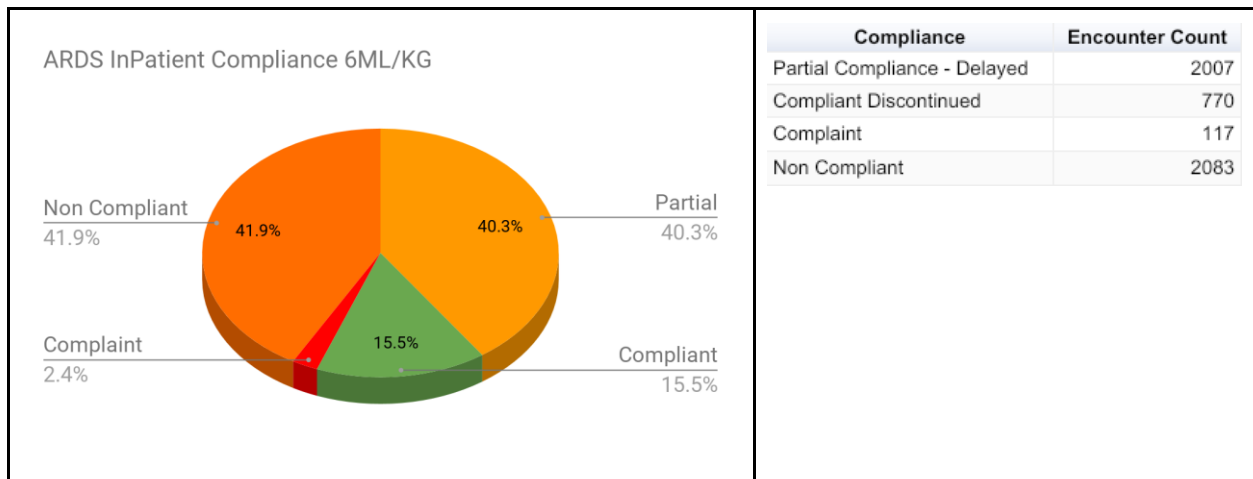
Bime Inpatient Compliance Rate <= 6mL/KG IBW



ARDS ED Compliance Rate \leq 6mL/KG IBW



ARDS Inpatient Compliance Rate \leq 6mL/KG IBW



Appendix: ARDS Diagnosis ICD Codes used to flag ARDS Cohort

[ARDS Cohort](#)

ICD Code	Label
518.5	Pulmonary insufficiency following trauma and surgery
518.51	Acute respiratory failure following trauma and surgery
518.52	Other pulmonary insufficiency, not elsewhere classified, following trauma and surgery
518.53	Acute and chronic respiratory failure following trauma and surgery
518.82	Other pulmonary insufficiency, not elsewhere classified
J80	Acute respiratory distress syndrome
J95.1	Acute pulmonary insufficiency following thoracic surgery
J95.2	Acute pulmonary insufficiency following nonthoracic surgery
J95.3	Chronic pulmonary insufficiency following surgery
J95.821	Acute postprocedural respiratory failure
J95.822	Acute and chronic postprocedural respiratory failure
J96.00	Acute respiratory failure, unsp w hypoxia or hypercapnia
J96.01	Acute respiratory failure with hypoxia
J96.02	Acute respiratory failure with hypercapnia
J96.20	Acute and chr resp failure, unsp w hypoxia or hypercapnia
J96.21	Acute and chronic respiratory failure with hypoxia
J96.22	Acute and chronic respiratory failure with hypercapnia

Appendix - Frequency of Encounters / Code

[ARDS Cohort](#)

Encounter Count	Code
5089	J96.01
1638	J96.00
1493	J96.02
1428	J96.21
1025	J96.22
732	J80
606	518.82
304	J96.20
157	J95.821
55	518.51
43	518.52
12	J95.822
5	518.53
3	J95.2
2	J95.1

Appendix - Bime Diagnosis Inclusion

Bime ARDS Cohort

ICD Code	Label
518.4	Acute edema of lung, unspecified
518.51	Acute respiratory failure following trauma and surgery
518.52	Other pulmonary insufficiency, not elsewhere classified, following trauma and surgery
518.53	Acute and chronic respiratory failure following trauma and surgery
518.7	Transfusion related acute lung injury (TRALI)
518.81	Acute respiratory failure
518.82	Other pulmonary insufficiency, not elsewhere classified
518.84	Acute & chronc resp fail
785.52	Septic shock
995.92	Severe sepsis
J80	Acute respiratory distress syndrome
J81.0	Acute pulmonary edema
J95.1	Acute pulmonary insufficiency following thoracic surgery
J95.2	Acute pulmonary insufficiency following nonthoracic surgery
J95.3	Chronic pulmonary insufficiency following surgery
J95.821	Acute postprocedural respiratory failure
J95.822	Acute and chronic postprocedural respiratory failure
J95.84	Transfusion-related acute lung injury (TRALI)
J96.00	Acute respiratory failure, unsp w hypoxia or hypercapnia
J96.01	Acute respiratory failure with hypoxia
J96.02	Acute respiratory failure with hypercapnia
J96.20	Acute and chr resp failure, unsp w hypoxia or hypercapnia
J96.21	Acute and chronic respiratory failure with hypoxia
J96.22	Acute and chronic respiratory failure with hypercapnia
J96.90	Respiratory failure, unsp, unsp w hypoxia or hypercapnia
J96.91	Respiratory failure, unspecified with hypoxia
J96.92	Respiratory failure, unspecified with hypercapnia
R65.20	Severe sepsis without septic shock
R65.21	Severe sepsis with septic shock

Appendix - Bime Diagnosis Exclusion

[Bime ARDS Cohort](#)

ICD Code	Label
428.0	Congestive heart failure, unspecified
493.22	Chronic obstructive asthma with (acute) exacerbation
493.91	Asthma, unspecified type, with status asthmaticus
493.92	Asthma, unspecified type, with (acute) exacerbation
I50.20	Unspecified systolic (congestive) heart failure
I50.21	Acute systolic (congestive) heart failure
I50.22	Chronic systolic (congestive) heart failure
I50.23	Acute on chronic systolic (congestive) heart failure
I50.30	Unspecified diastolic (congestive) heart failure
I50.31	Acute diastolic (congestive) heart failure
I50.32	Chronic diastolic (congestive) heart failure
I50.33	Acute on chronic diastolic (congestive) heart failure
I50.40	Unsp combined systolic and diastolic (congestive) hrt fail
I50.41	Acute combined systolic and diastolic (congestive) hrt fail
I50.42	Chronic combined systolic and diastolic hrt fail
I50.43	Acute on chronic combined systolic and diastolic hrt fail
I50.9	Heart failure, unspecified
J44.1	Chronic obstructive pulmonary disease w (acute) exacerbation
J45.901	Unspecified asthma with (acute) exacerbation
J45.902	Unspecified asthma with status asthmaticus

Bime Procedure Inclusion

[Bime ARDS Cohort](#)

ICD Code	Label
5A1935Z	Respiratory Ventilation, Less than 24 Consecutive Hours
5A1945Z	Respiratory Ventilation, 24-96 Consecutive Hours
5A1955Z	Respiratory Ventilation, Greater than 96 Consecutive Hours
96.70	Continuous invasive mechanical ventilation of unspecified duration
96.71	Continuous invasive mechanical ventilation for less than 96 consecutive hours
96.72	Continuous invasive mechanical ventilation for 96 consecutive hours or more

Appendix - Intubation Procedure Codes

Intubation Cohort

Code	Label
0BH17EZ	Insertion of Endotracheal Airway into Trachea, Via Opening
0BH18EZ	Insertion of Endotracheal Airway into Trachea, Endo
96.04	Insertion of endotracheal tube
09HN7BZ	Insertion of Airway into Nasopharynx, Via Opening
09HN8BZ	Insertion of Airway into Nasopharynx, Endo
96.01	Insert nasopharynx airway
0CHY7BZ	Insertion of Airway into Mouth and Throat, Via Opening
0CHY8BZ	Insertion of Airway into Mouth and Throat, Endo
96.02	Insertion of oropharyngeal airway
96.03	Insertion of esophageal obturator airway
0B717DZ	Dilation of Trachea with Intraluminal Device, Via Opening
0B718DZ	Dilation of Trachea with Intraluminal Device, Endo
0BH072Z	Insertion of Monitor Dev into Tracheobronc Tree, Via Opening
0BH073Z	Insert of Infusion Dev into Tracheobronc Tree, Via Opening
0BH07DZ	Insert of Intralum Dev into Tracheobronc Tree, Via Opening
0WHQ73Z	Insertion of Infusion Device into Resp Tract, Via Opening
0WHQ7YZ	Insertion of Other Device into Resp Tract, Via Opening
96.05	Other intubation of respiratory tract
5A1935Z	Respiratory Ventilation, Less than 24 Consecutive Hours
5A1945Z	Respiratory Ventilation, 24-96 Consecutive Hours
5A1955Z	Respiratory Ventilation, Greater than 96 Consecutive Hours
96.70	Continuous invasive mechanical ventilation of unspecified duration
5A1935Z	Respiratory Ventilation, Less than 24 Consecutive Hours
5A1945Z	Respiratory Ventilation, 24-96 Consecutive Hours
96.71	Continuous invasive mechanical ventilation for less than 96 consecutive hours
5A1955Z	Respiratory Ventilation, Greater than 96 Consecutive Hours
96.72	Continuous invasive mechanical ventilation for 96 consecutive hours or more

Appendix: Intubation Observation Codes

[Intubation Cohort](#)

Source	Code (s)	Value(s)
Respiratory Observation	Mask/Delivery Type	Endotracheal
Respiratory Observation	Mask/Delivery Type	Trach

Available Respiratory Event Types

code	Count
BiPAP/CPAP Alarms On and Functional	10893
BiPAP/CPAP Exhaled Tidal Volume	45913
BiPAP/CPAP Expiratory Pressure	52510
BiPAP/CPAP Frequency	57773
BiPAP/CPAP Inspiratory Pressure	47061
BiPAP/CPAP Inspiratory Time	8056
BiPAP/CPAP Machine ID	10440
BiPAP/CPAP Minute Volume	43466
BiPAP/CPAP Mode	57701
BiPAP/CPAP Oxygen Flow Rate	1719
BiPAP/CPAP Peak Insp Press (PIP)	33193
BiPAP/CPAP Resp Rate Total	49721
BiPAP/CPAP Set Rate	40828
BiPAP/CPAP Start Date/Time	8167
BiPAP/CPAP Stop Date/Time	1290
FIO2	611066
I:E Ratio Measured	146380
Inspiratory Flow Rate	146731
Inspiratory Time	97679
Mask/Delivery Type	229076
Mean Airway Pressure	222480
Minute Volume	223973
Peak Inspiratory Pressure	247082
Plateau Pressure	95654
Pressure Support	49193
Respiratory Rate Total (Assisted)	286792
Respiratory Rate, Set	238407
Set Positive End Expiratory Pressure	276805
Tidal Volume Set	210227
Tidal Volume Set (L)	1411
Tidal Volume, Exhaled	227797
Ventilator Mode	289002

Respiratory Events Summary Metrics - related to Tidal Volume

Clinical_Event	event_count	min	max	mean	median	stddev
Tidal Volume, Exhaled	228237	0	8701	483.76355623766716	472.0	152.700026426521
Set Positive End Expiratory Pressure	277798	0	50	6.0422096756178325	5.0	2.577756151793598
Tidal Volume Set (L)	1413	0	783	167.01003584229392	0.0	222.85336561916512
Tidal Volume Set	210822	-500	60040	456.629710351377	450.0	197.59290689440707
BiPAP/CPAP Exhaled Tidal Volume	46143	10	2000	481.449276935771	453.0	169.47532147699818

Respiratory Events Summary Metrics - Any with mention of pressure or Plateau or Peep

Clinical_Event	event_count	min	max	mean	median	stddev
Pressure Support	49313	0	50	9.879614767255216	10.0	4.479056603817354
BiPAP/CPAP Expiratory Pressure	52809	0	89	6.377579274768624	5.0	2.4409337497111103
Set Positive End Expiratory Pressure	277798	0	50	6.0422096756178325	5.0	2.577756151793598
Mean Airway Pressure	222959	-8	913	11.676425442533482	11.0	7.882163463493426
BiPAP/CPAP Inspiratory Pressure	47334	0	45	14.142113394425515	14.0	3.5373104557634574
Peak Inspiratory Pressure	247632	0	100	25.77128944922617	25.0	8.667820733450569