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Extubation failure in ELBW infants: Art, Gamble or Science?

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Professor of Pediatrics
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Disclosure

I have no financial relationships to disclose or Conflicts of Interest to resolve

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Automated Prediction of EXtubation Readiness in Extremely Preterm Infants: The APEX Multicenter Study

APEX investigators:

Wissam Shalish, Lara Kanbar, Charles Onu, Lajos Kovacs, MD, Sanjay Chawla, MD, Martin Keszler, MD, Smita Rao, Karen Brown, MD, Doina Precup, PhD, Robert E Kearney, PhD and Guilherme M Sant'Anna, MD, PhD

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Jewish General Hospital

Children's Hospital of Michigan
DMC
DETROIT MEDICAL CENTER / WAYNE STATE UNIVERSITY

Women & Infants

Why extubation failure?

- Observation:
  - High % of extremely preterm infants are **mechanically ventilated**
  - **Extubation failure rates are quite high** and generate clinical frustration → **ELBW infants: 40-58%** compared to **Children: 6% and Adults: 10%**
  - Some previously stable infants **worsened after re-intubation**
- **Lack of robust science** to help on decisions related to extubation readiness

Walsh et al, J Peds 2005
Carlo W et al, NEJM 2010
Stoll B et al, JAMA 2015

Case

- Male baby born at 22:00pm with 24^4 weeks with BW = 680 g. Complete antenatal steroids

- Tried on bubble CPAP in the DR but intubated at 2h of life for high O_2 needs (60%). Surfactant was administered and MV started

- Next day at rounds (~12h of life) – on VG ventilation:
  - PIP = 12 cmH_2O
  - PEEP = 5 cmH_2O
  - V_T = 5 ml/kg
  - Rate = 40 bpm
  - FiO_2 = 28%
  - MAP = 6-7 cmH_2O

Arterial blood gas:
pH = 7.33
$PaCO_2$ = 45
PaO_2 = 55
$HCO3^-$ = 20
BE = - 3.2

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International survey on periextubation practices in extremely preterm infants

H Al-Mandari,[1] W Shalish,[1] E Dempsey,[2] M Keszler,[3] P G Davis,[4] G Sant'Anna[5]

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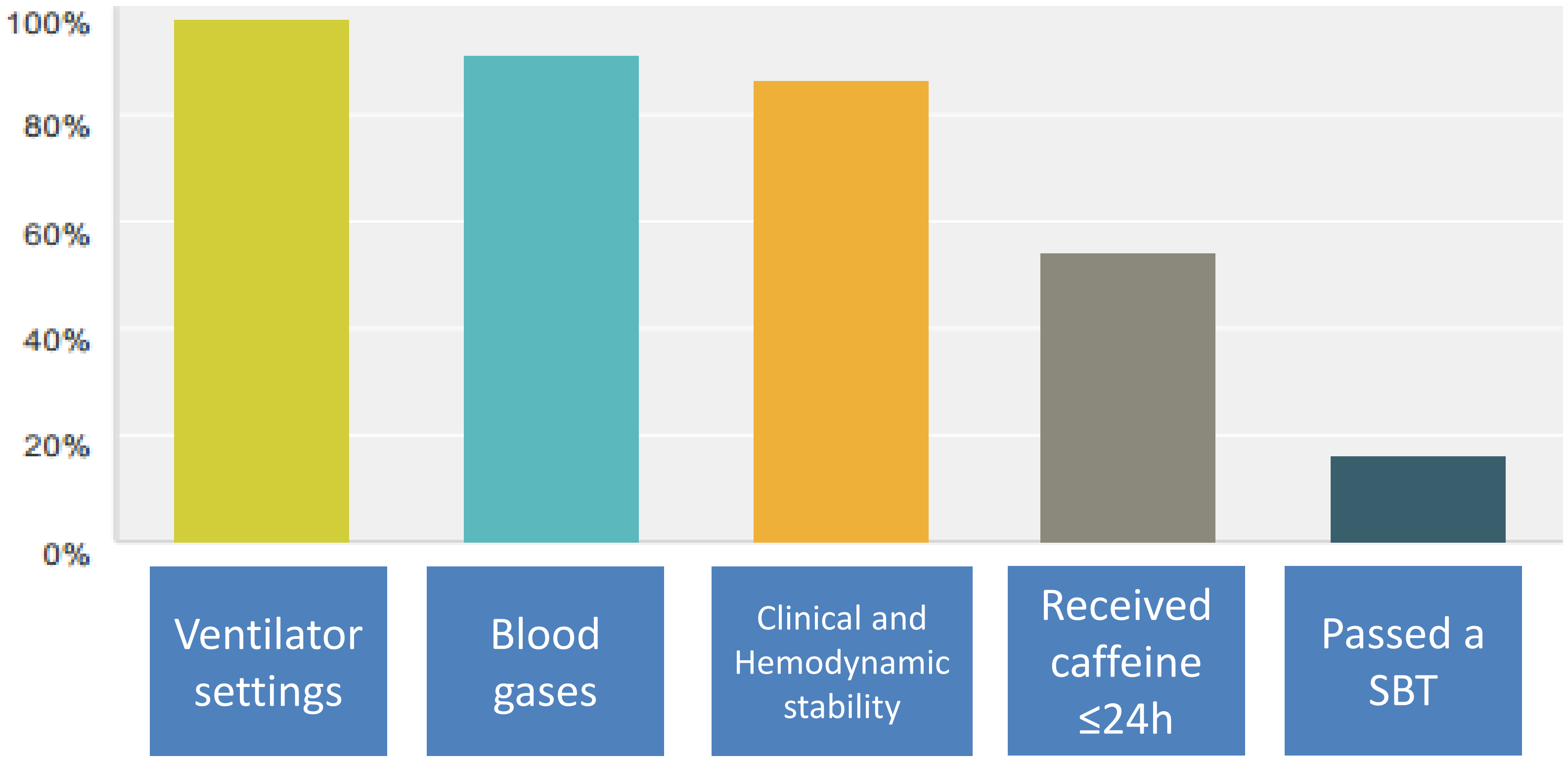
In your unit, EPT infants are extubated based on what criteria?



Al-Mandari H et al, ADC Fetal & Neonatal, 2015

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When do you usually extubate EPT infants in your unit?

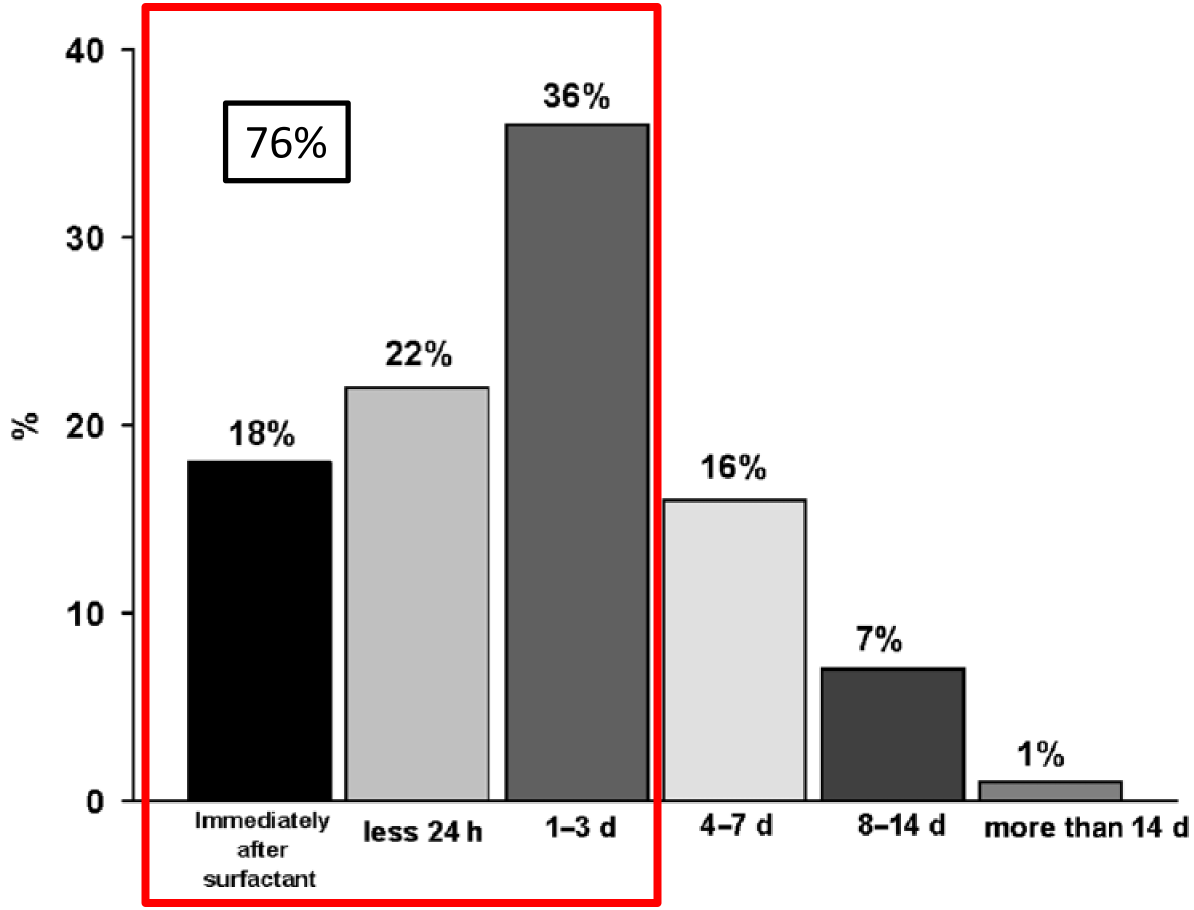

Figure 1 Age at first extubation attempt.

Al-Mandari H et al, ADC Fetal & Neonatal, 2015

Age at first extubation

- Highly variable across the literature
  - Not always reported

  Median values → ranges from **2.5 to 36 days**

COIN trial (2008) = > 50% extubated by **day 3 of life**
NIPPV trial (2011) = median **3.5** (2-7) days of life
SUPPORT trial (2017) = median **2.5** (2-9) days of life

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ORIGINAL ARTICLES

Age at first extubation attempt and death or respiratory morbidities in extremely preterm infants

Wissam Shalish, MD, PhD[1], Martin Keszler, MD[2], Lajos Kovacs, MD[3], Sanjay Chawla, MD[4], Samantha Latremouille, MSc[1], Marc Beltempo, MD, MSc[1], Robert E. Kearney, PhD[5], and Guilherme M. Sant'Anna, MD, PhD[1]

International survey on periextubation practices in extremely preterm infants

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When do you usually extubate EPT infants in your unit?

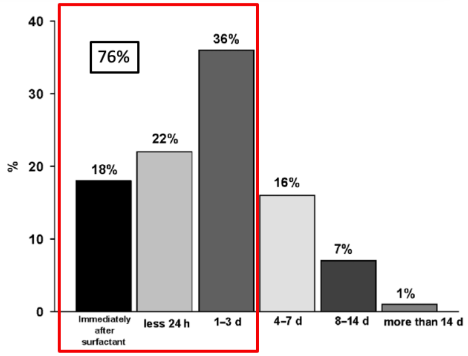
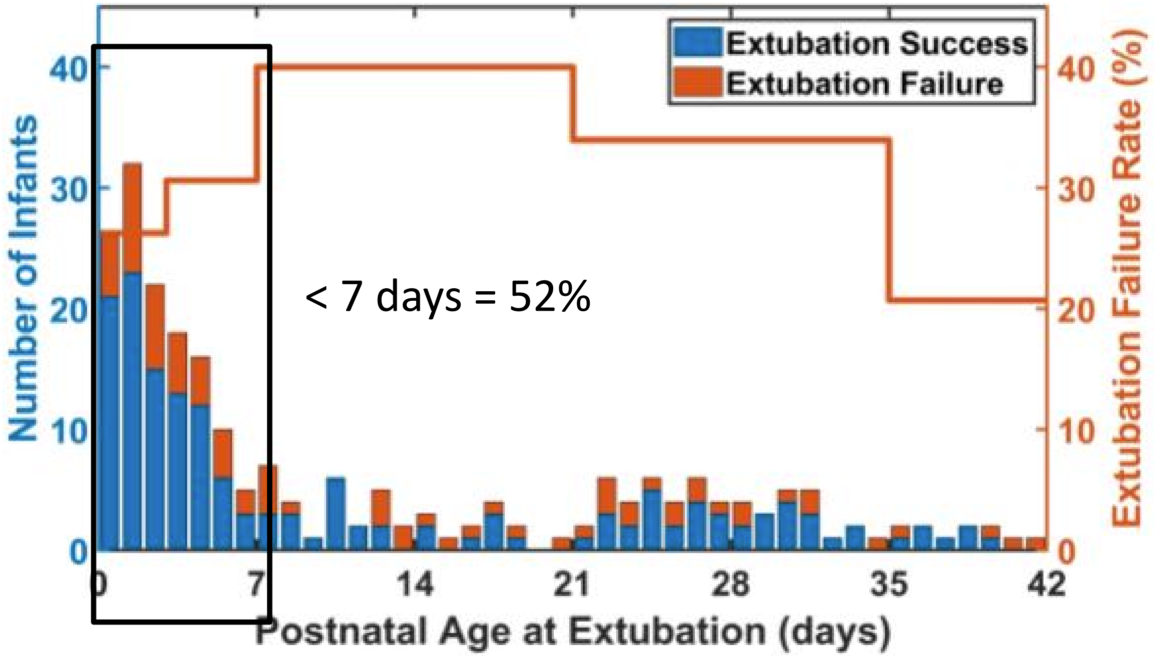


Figure 1 Age at first extubation attempt.



Legend: An additional 17 infants were extubated beyond 42 days of life. The probability of extubation failure (red line, Y2 axis) was computed for the postnatal age bins corresponding to days of life 1-3 (n=80), 4-7 (n=49), 8-21 (n=40), 22-35 (n=53) and > 35 days (n=28).

J Pediatrics, 2022

Questions

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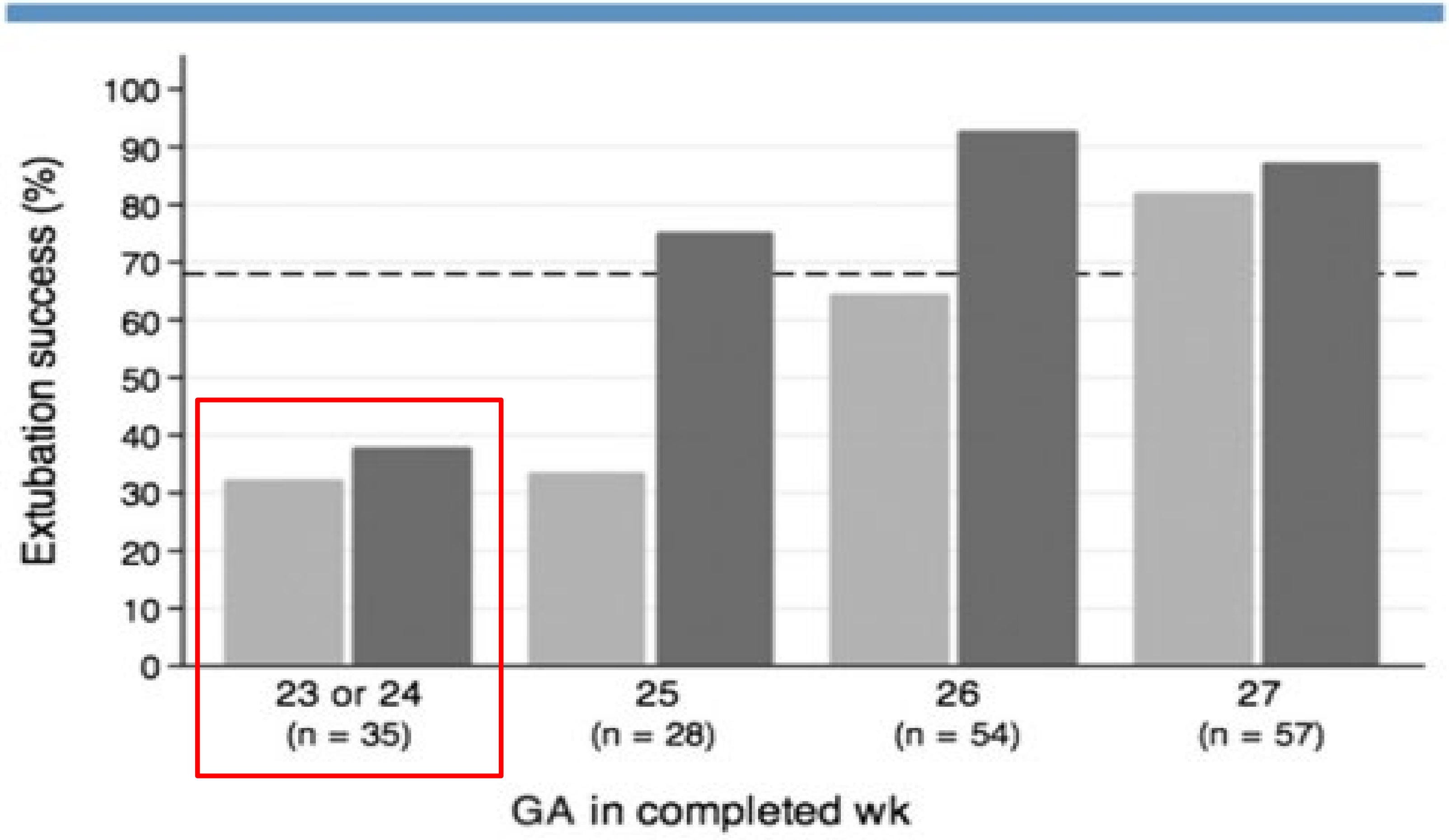
Gestational Age



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Manley et al J Pediatrics, 2016

N=250 infants
Enrolled in APEX Study and received
MV within ≤ 24h of life

N=129 (52%)
Early Extubation
Day of life 1-7

N=93 (37%)
Late Extubation
Day of life 8-35

N=93
Extubation
Success

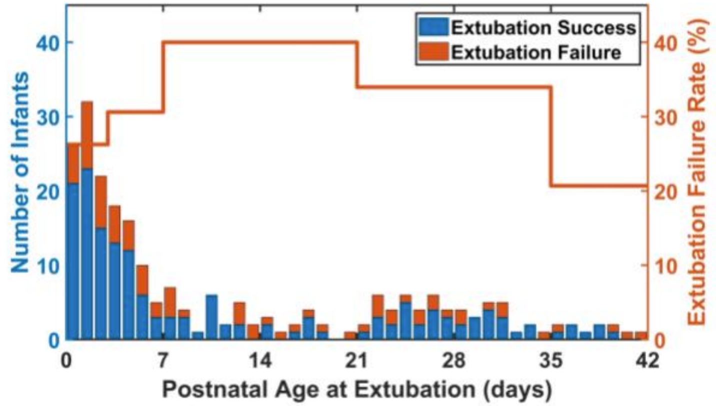
N=36
Extubation
Failure

N=59
Extubation
Success

N=34
Extubation
Failure

72% success

63% success



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Definition of Successful Extubation

1. Criteria used to define failure

2. Observation window (between extubation → re-intubation) selected

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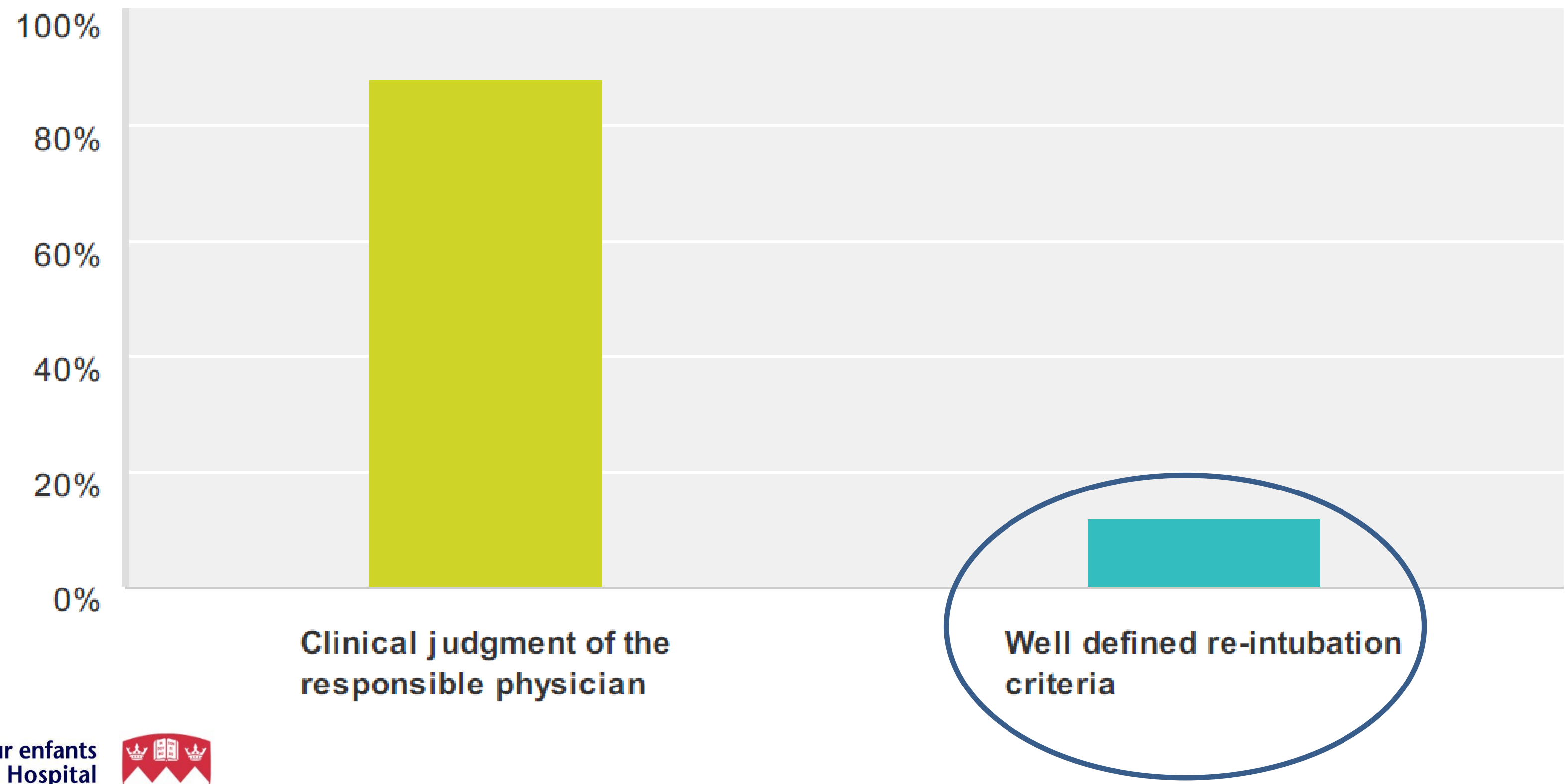
Criteria for extubation failure ?



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Al-Mandari H et al, ADC Fetal & Neonatal, 2015

Definition of CPAP or NIV failure

FiO_2	Apnea	PCO_2	Other	Initial CPAP	Max CPAP
30% to >75%	1 to > 4/h 1 to 2 episodes of bag & mask ventilation	60 to > 70 mmHg pH=7.20 to 7.22	Only 1 study included hemodynamic stability	≥ 4 to 8 cmH_2O	5 trials = not stated 7cmH_2O

Wright CJ et al, J Peds, 2016

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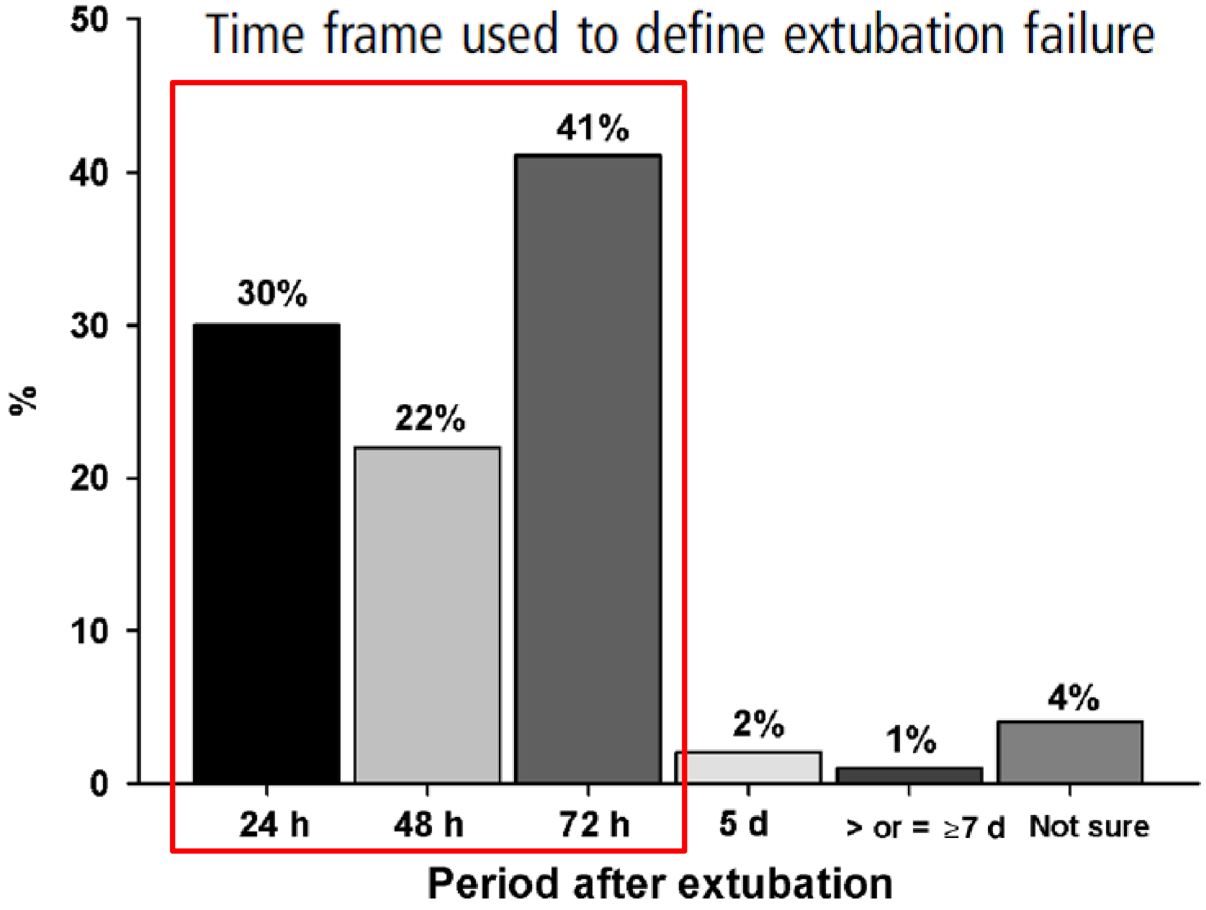

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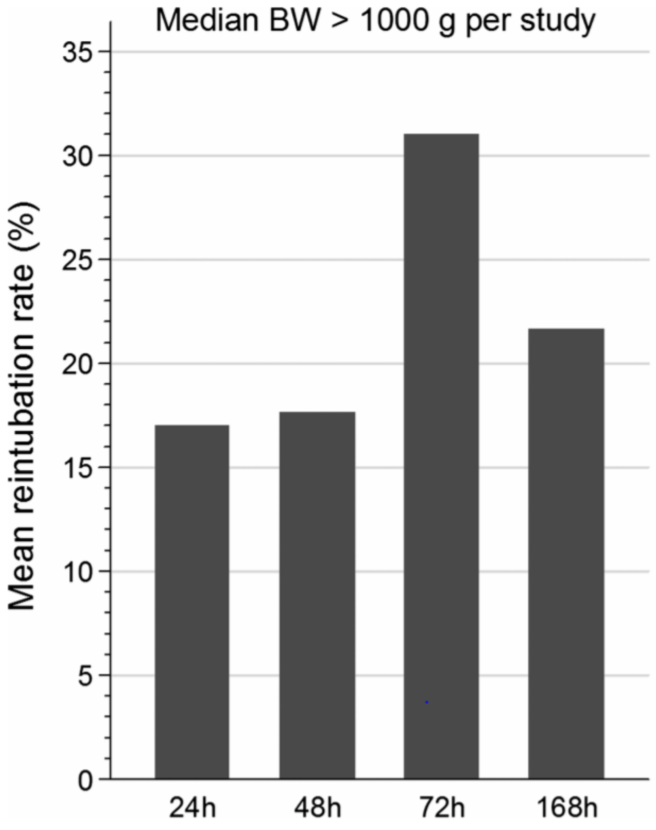
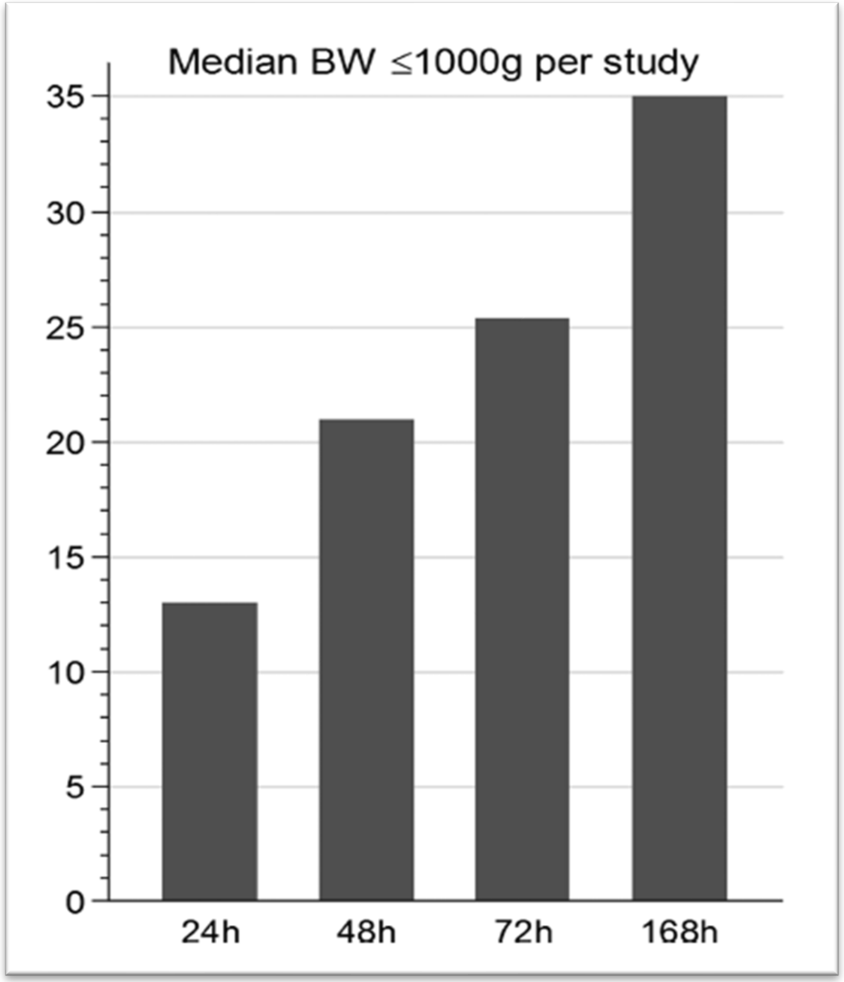
Al-Mandari H et al, ADC Fetal & Neonatal, 2015

Definitions of extubation success in very premature infants: a systematic review

Annie Giaccone,[1] Erik Jensen,[1] Peter Davis,[2] Barbara Schmidt[1,3]





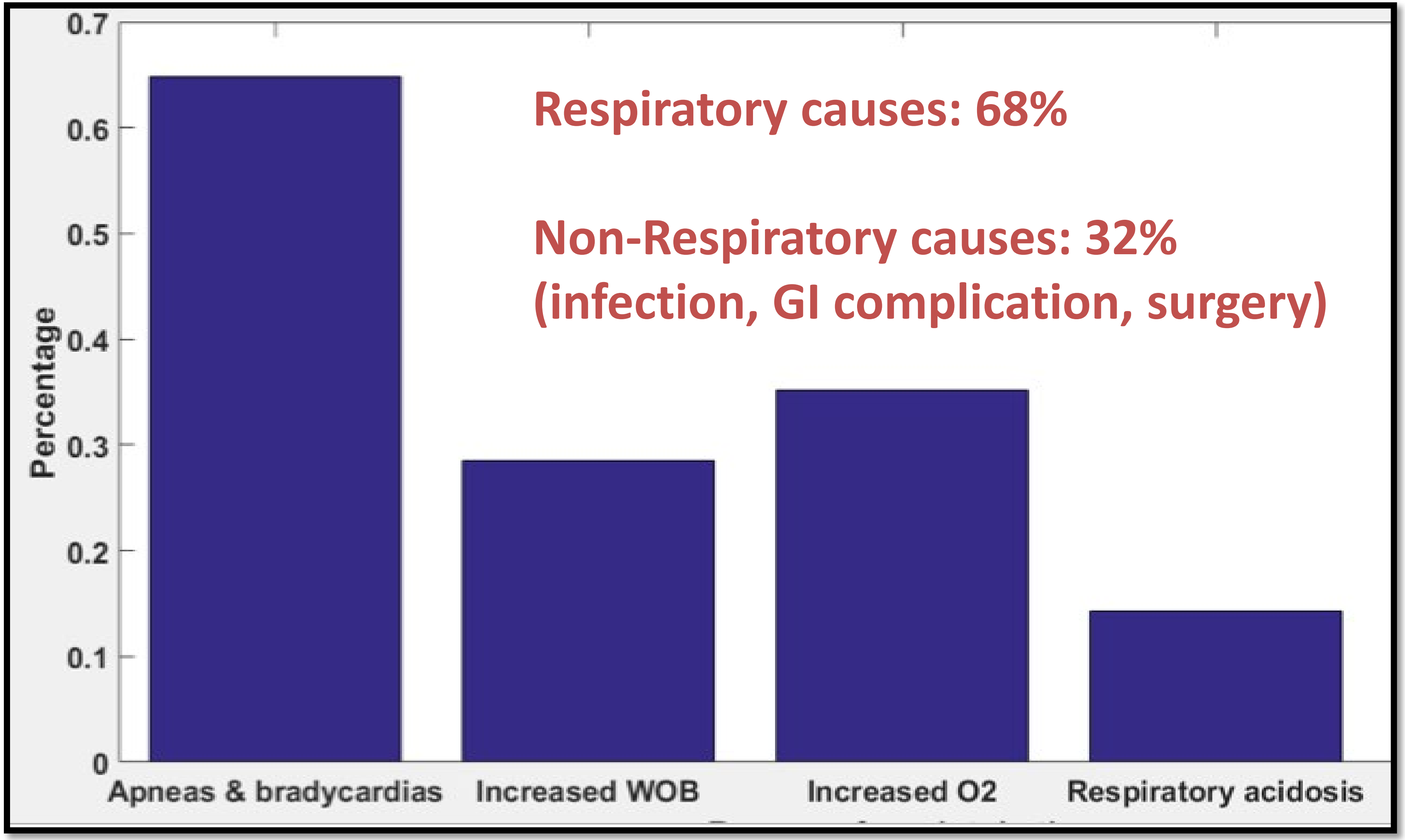
ADC F&N, 2014

Choice of Observation Window

- Too short – may miss reintubations attributable to respiratory causes

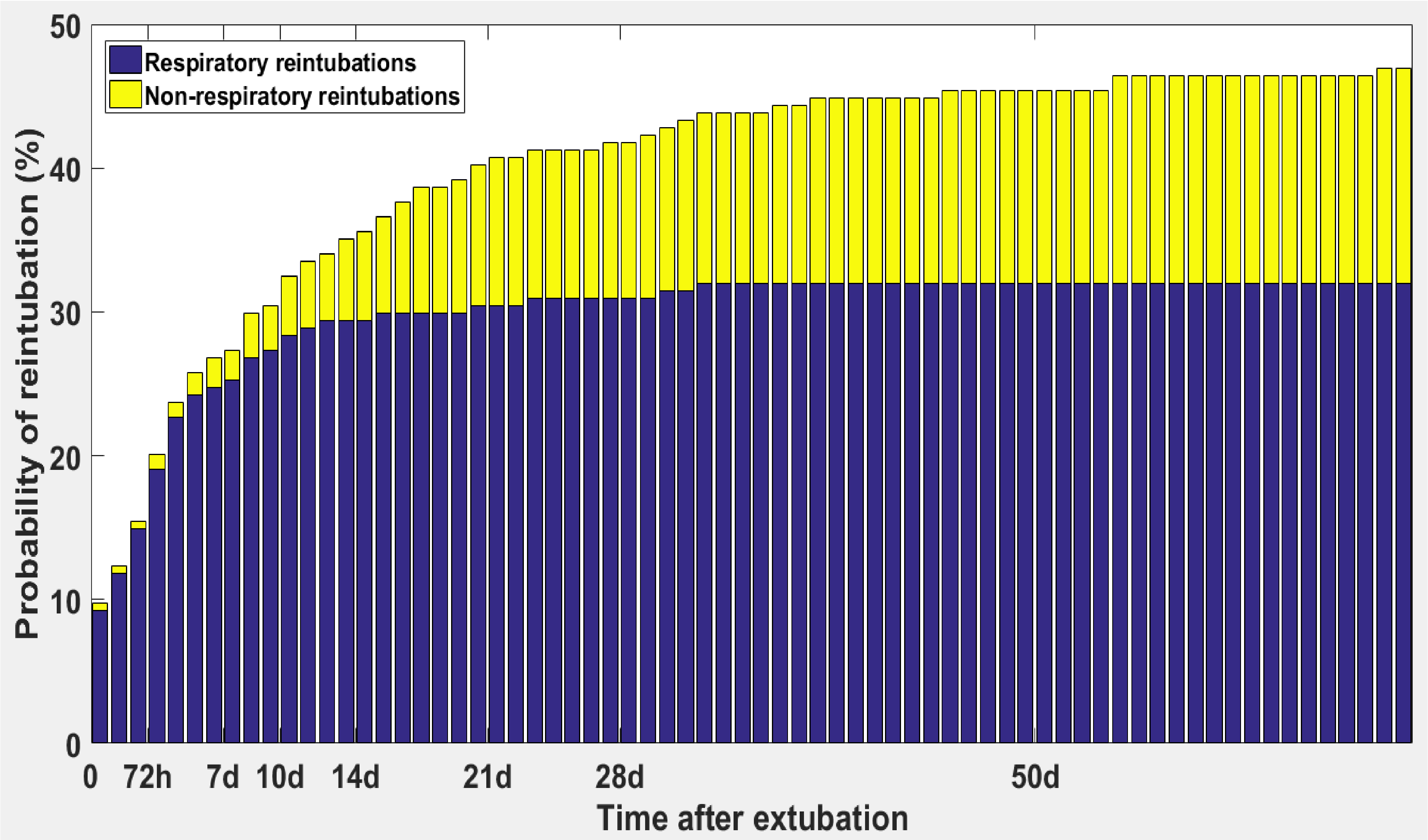
- Too long – may capture reintubations caused by non-respiratory reasons
  - Infection
  - Necrotizing enterocolitis
  - Elective procedures

Respiratory Causes of Reintubation



Shalish et al Pediatr Res 2018

Time frame - extubation failure



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Shalish W et al, Ped Res 2018

Time frame - extubation failure

- **Observation window of 7 days** captures:
  - ~ 85% of respiratory and < 15% of non-respiratory reintubations
- Any study testing the effects of different respiratory therapies should only include **failures related to respiratory reasons**

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Shalish W et al, Ped Res 2018

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Neonates and Extubation Failure

- The procedural aspect of **intubation** is associated with adverse outcomes, especially in the emergency setting
  - Changes in brain activity
  - Airway trauma
  - Hemodynamic instability
  - Death

Shangle et al. J Pediatrics. 2012
Hatch et al. J Pediatrics. 2015

Neonates and Extubation Failure

Secondary analyses from 2 large RCTs suggest that **extubation failure** is independently associated with:

- Death prior to discharge
- BPD among survivors
- Death or BPD
- Intraventricular hemorrhage grade 3 or 4
- Prolonged respiratory support
- Length of hospitalization

Manley et al, J Peds 2016
Chawla et al, J Peds 2017

Reintubation – Morbidities/Mortality

1. What exactly increases the risk of morbidity?
   – The reintubation itself?
   – The resumption of mechanical ventilation?

2. Do all reintubations have the same clinical implications?

Original Investigation

Effects of Multiple Ventilation Courses and Duration of Mechanical Ventilation on Respiratory Outcomes in Extremely Low-Birth-Weight Infants

Erik A. Jensen, MD; Sara B. DeMauro, MD, MSCE; Michael Kornhauser, MD; Zubair H. Aghai, MD; Jay S. Greenspan, MD; Kevin C. Dysart, MD

- 3343 infants with BW <1000g intubated and receiving MV
- Increased risk of BPD was associated with duration of MV

JAMA Pediatr. 2015

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Jay S. Greenspan, MD; Kevin C. Dysart, MD

- 66% (n=2206) needed re-intubation and 60% (n=1323) of these required a total of ≥ 3 re-intubations

- Thus, 40% of total were re-intubated ≥ 3 times → **independently associated with BPD**

JAMA Pediatr. 2015

Reintubation and BPD

2 LIMITATIONS – did not account for:

Age at First Extubation

Day of life at extubation

0 24h 5d 7d Anytime

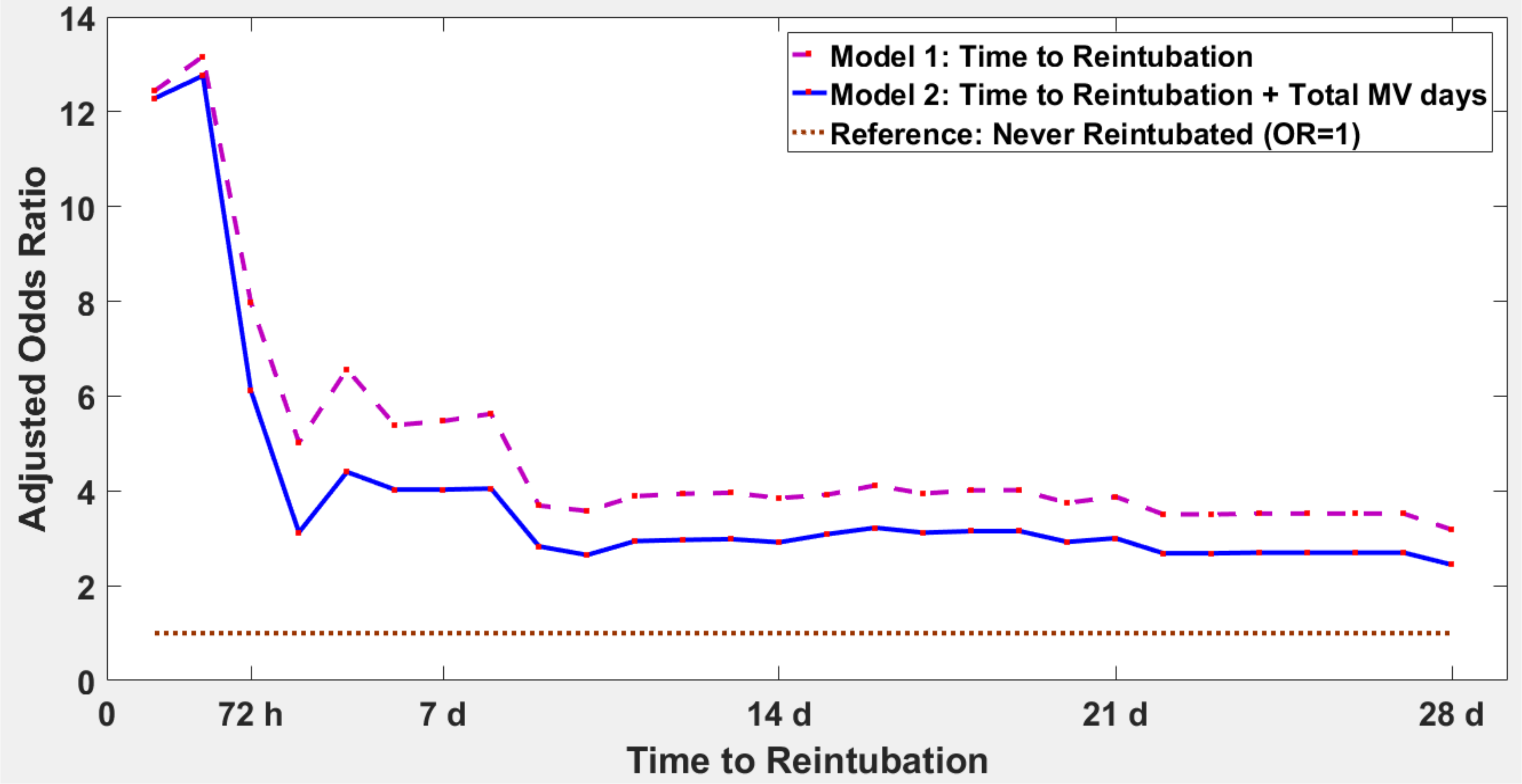
Time to Reintubation

Extubation **Reintubation**

0 24h 5d 7d Anytime

Jensen et al. JAMA Pediatr 2015

Time to Reintubation and Death/BPD



Adjusted for BW, postnatal infection, postnatal steroids, NEC and site

Shalish et al J Pediatr 2018

Reintubation and Morbidities
SUMMARY

- Exposure to MV remains one of the most important risk factors for increased death/BPD

- But also need to be mindful:
  - Multiple (≥ 3) reintubations
  - Age at extubation
  - Reintubations within 48h after extubation

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Implementation of a Respiratory Therapist-Driven Protocol for Neonatal Ventilation: Impact on the Premature Population

Fernanda Hermeto, MD, Marcela Nosralla Bottino, MD, Kelly Vaillancourt, RRT, Guilherme Mendes Sant'Anna, MD, PhD, FRCPC

Department of Pediatrics, McMaster University, Hamilton, Ontario, Canada

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Extubation:

BW ≤ 1000g: MAP < 7 cmH_2O and FiO2 ≤ 0.30
BW > 1000g: MAP < 8 cmH_2O and FiO2 ≤ 0.30

Re-intubation:

- FiO2 > 0.6 to maintain SaO2 > 88% or PaO2 > 45 mmHg
- PaCO2 (arterial) > 55 to 60 with a pH < 7.25
- Apnea requiring bag and mask ventilation
- Evidence of increased WOB (retractions, grunting and chest wall distortion) + abnormal chest x-ray

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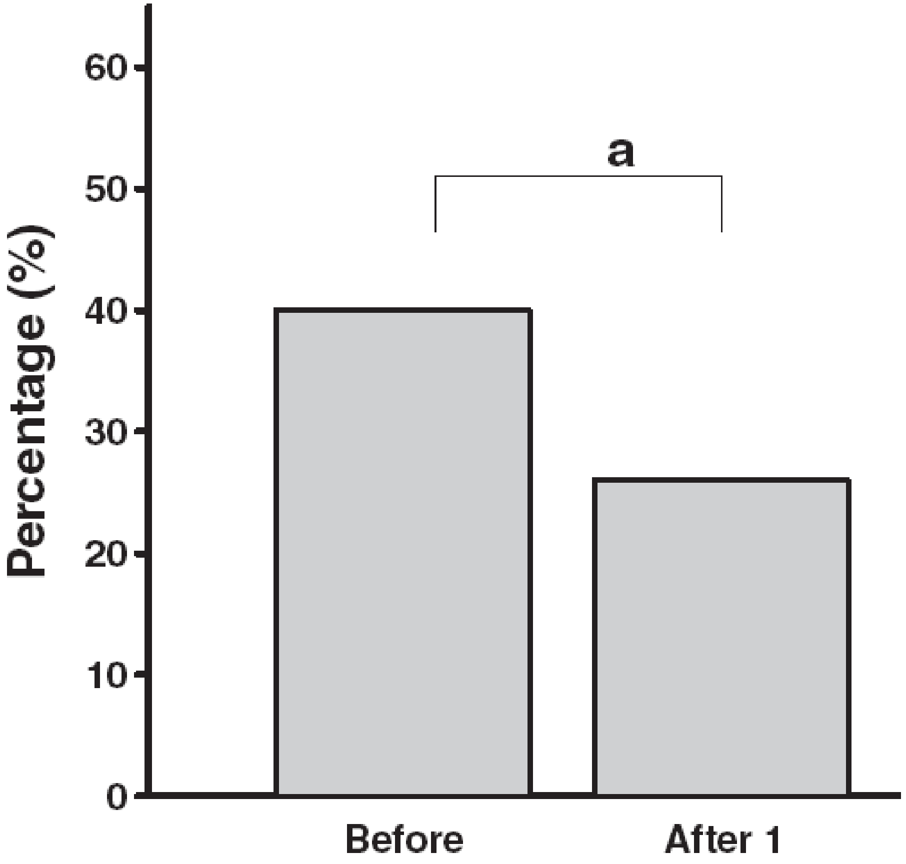
Extubation failure rate



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JAMA Pediatrics | Original Investigation

Interventions to Improve Rates of Successful Extubation in Preterm Infants

A Systematic Review and Meta-analysis

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- Preterm infants should be extubated to noninvasive respiratory support
- Caffeine should be used routinely
- Postnatal corticosteroids should be used judiciously, weighing up the competing risks of BPD and neurodevelopmental harm

Ferguson et al, JAMA 2017

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Solving the Extubation Equation: Successfully Weaning Infants Born Extremely Preterm from Mechanical Ventilation

"Two important issues remain for researchers and clinicians":

1. Accurate tests of extubation readiness are required to enable clinicians to minimize the duration of MV while avoiding the risks of re-intubation

Manley B and Davis P, J Peds 2017

Predictors of Extubation Readiness

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- Systematic Review and Meta-analysis of Diagnostic Test Accuracy

- Objectives:
  - To identify predictors of extubation success
  - To determine their accuracy compared to clinical judgment alone

Shalish et al. ADC Fetal & Neonatal Ed, 2019

Predictors of Extubation Readiness

- Tests performed in many ways:
  - Duration: few seconds to 24 hours
  - PEEP: 0 to 6 cm H_2O
  - Variable clinical and physiological measurements

- 31 predictors included for meta-analysis

Shalish et al. ADC Fetal & Neonatal Ed, 2019

Predictors of Extubation Readiness

Study	TP	FP	FN	TN	Sensitivity (95% CI)	Specificity (95% CI)
Kawadia 2000 - CRS 0.8 ml/cmH2O/kg	11	4	9	6	0.55 [0.32, 0.77]	0.60 [0.26, 0.88]
Bhat 2016 - TTdi 0.08	11	1	8	10	0.58 [0.33, 0.80]	0.91 [0.59, 1.00]
Kawadia 2000 - VT 5.5ml/kg	12	4	8	6	0.60 [0.36, 0.81]	0.60 [0.26, 0.88]
Davidson 2008 - RR 63 bpm	13	8	7	8	0.65 [0.41, 0.85]	0.50 [0.25, 0.75]
Davidson 2008 - VT 4 ml/kg	13	9	7	6	0.65 [0.41, 0.85]	0.40 [0.16, 0.68]
Fox 1993 - %MVs 140	17	4	7	12	0.71 [0.49, 0.87]	0.75 [0.48, 0.93]
Davidson 2008 - RR/VT 22 bpm/ml/kg	15	9	5	6	0.75 [0.51, 0.91]	0.40 [0.16, 0.68]
Sillos 1992 - MIP 25	10	1	3	4	0.77 [0.46, 0.95]	0.80 [0.28, 0.99]
Dimitriou 2011 - TTmus 0.1	20	0	4	4	0.83 [0.63, 0.95]	1.00 [0.40, 1.00]
Kamlin 2006 - MVs 220ml/kg/min	33	5	6	6	0.85 [0.69, 0.94]	0.55 [0.23, 0.83]
Kawadia 2000 - VT 4 ml/kg	17	9	3	1	0.85 [0.62, 0.97]	0.10 [0.00, 0.45]
Kamlin 2006 - MVs/MVm 0.8	34	5	5	6	0.87 [0.73, 0.96]	0.55 [0.23, 0.83]
Vento 2004 - MVs 125ml/kg/min	27	0	3	11	0.90 [0.73, 0.98]	1.00 [0.72, 1.00]
Chawla 2013 - SBT	36	5	3	5	0.92 [0.79, 0.98]	0.50 [0.19, 0.81]
Chen 1992 - MIP 35	26	0	2	5	0.93 [0.76, 0.99]	1.00 [0.48, 1.00]
Kaczmarek 2013 - SBT + VI of Te	35	1	1	7	0.97 [0.85, 1.00]	0.88 [0.47, 1.00]
Kaczmarek 2013 - VI of Ti/Ttot	35	4	1	4	0.97 [0.85, 1.00]	0.50 [0.16, 0.84]
Kamlin 2006 - SBT	38	3	1	8	0.97 [0.87, 1.00]	0.73 [0.39, 0.94]
Kaczmarek 2013 - SBT + VI of Ti	36	2	0	6	1.00 [0.90, 1.00]	0.75 [0.35, 0.97]
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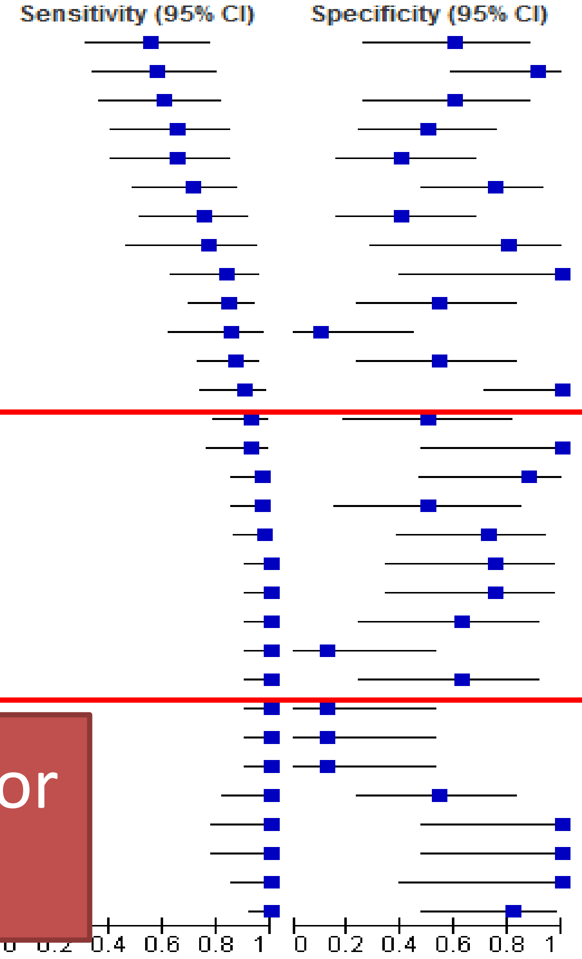
Kaczmarek 2013 - VI of Ti	36	7	0	1	1.00 [0.90, 1.00]	0.13 [0.00, 0.53]
Kaczmarek 2013 - VI of VT/Ti						
Kaczmarek 2013 - VI of VT						
Bhat 2016 - TTmus 0.19						
Currie 2011 - TTdi 0.15						
Currie 2011 - TTmus 0.18						
Dimitriou 2011 - TTdi 0.12						
Robles-Rubio 2015 - Respiratory						



Different definitions of PASS or FAIL the SBT

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Shalish et al. ADC Fetal & Neonatal Ed, 2019

JAMA Pediatrics | Original Investigation

Assessment of Extubation Readiness Using Spontaneous Breathing Trials in Extremely Preterm Neonates

Wissam Shalish, MD; Lara Kanbar, MSc; Lajos Kovacs, MD; Sanjay Chawla, MD; Martin Keszler, MD; Smita Rao;
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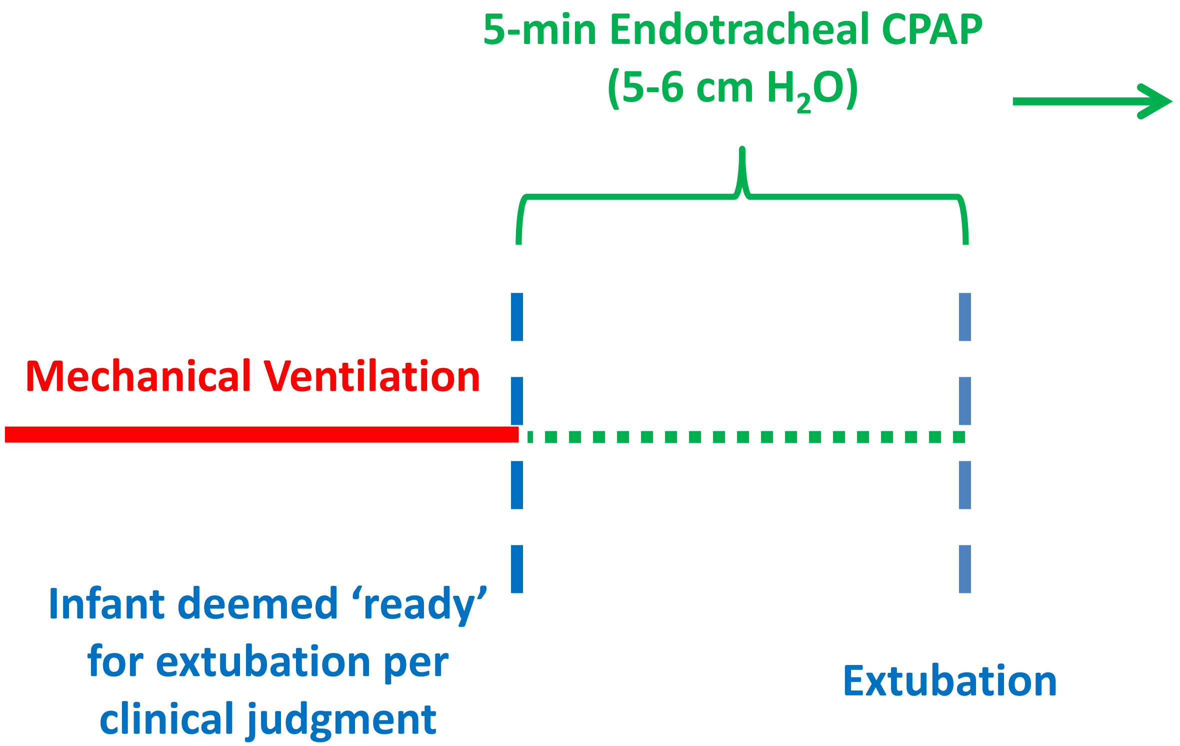

Objective

Describe Clinical Event Occurrence during 5-min ET-CPAP

Shalish et al, Dec 2019

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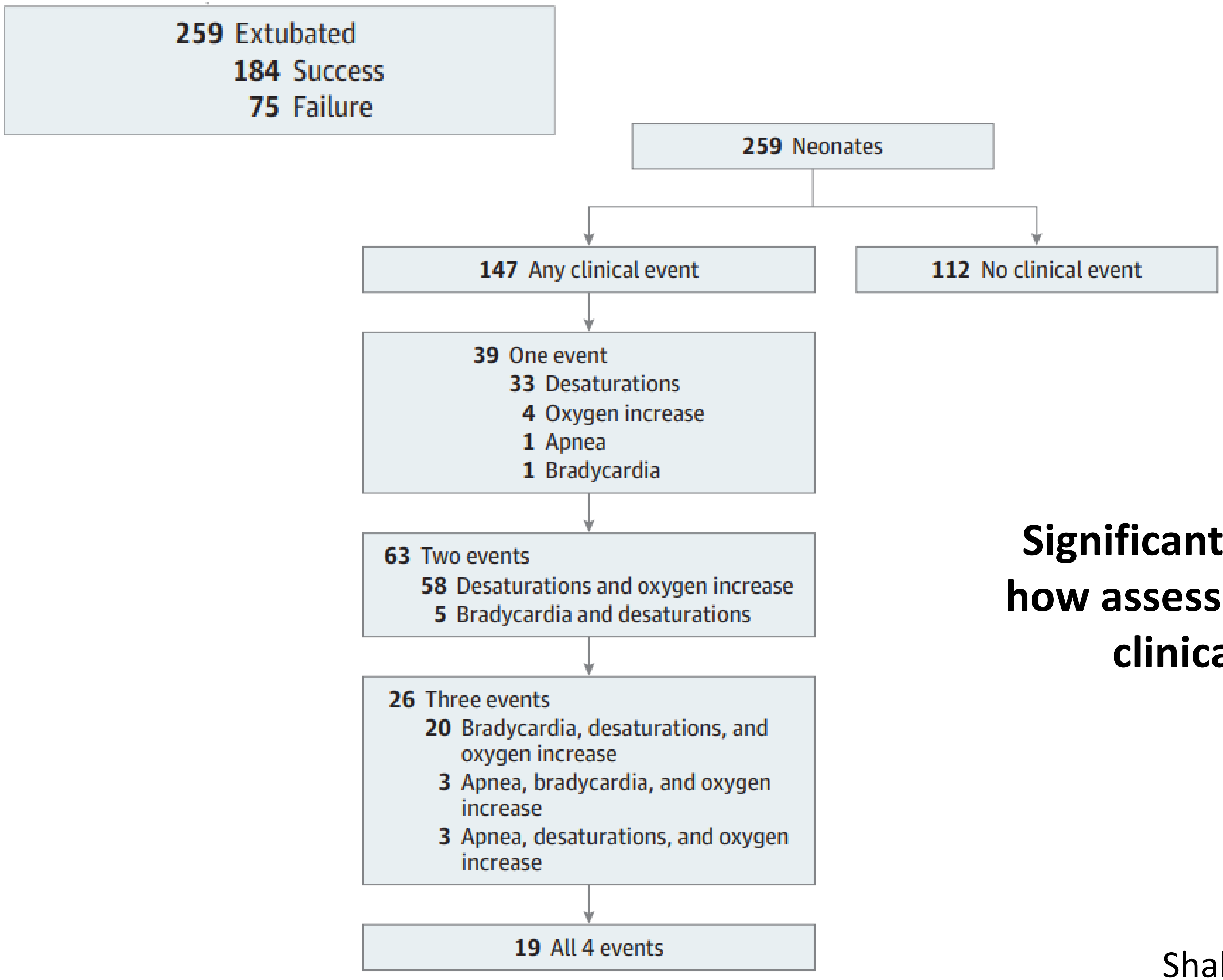
4 CLINICAL EVENTS DOCUMENTED DURING ET-CPAP	
A	Apnea requiring stimulation;
B	Presence and cumulative duration of Bradycardia (HR < 100 bpm)
D	Presence and cumulative duration of Desaturation (SpO_2 < 85%)
O_2	Need for supplemental Oxygen and maximum amount provided.

Shalish et al, Dec 2019



Significant variations in how assessors reacted to clinical events

Shalish et al, Dec 2019

JAMA Pediatrics | Original Investigation

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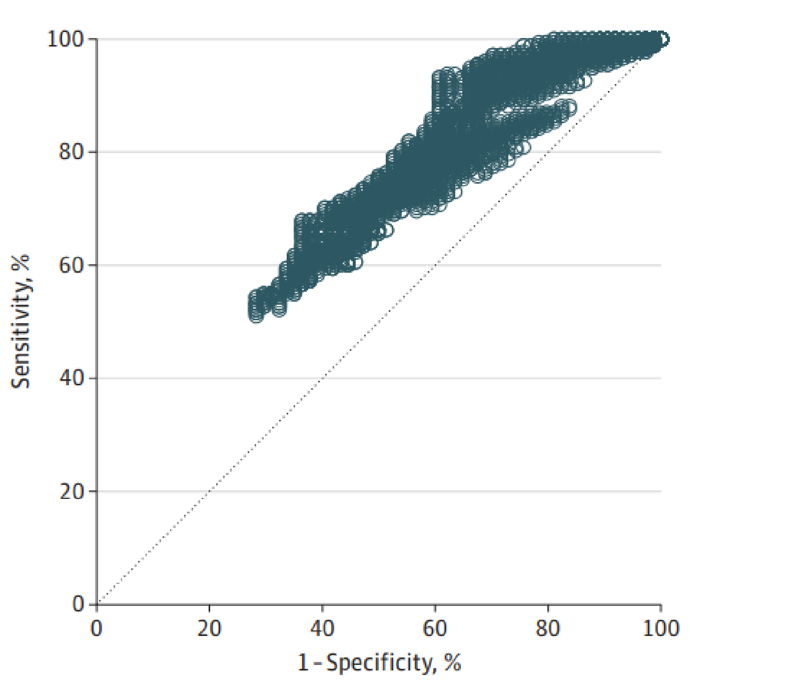
Total = **41,602 SBT pass/fail definitions** were evaluated, showing overall high sensitivity but **very low specificity**

Figure 3. Diagnostic Performance of 41 602 Spontaneous Breathing Trial (SBT) Definitions for Predicting Successful Extubation



- 5-min ET-CPAP exposed > 50% of infants to clinical instability
- SBTs still leave room for subjective interpretation

Shalish et al, Dec 2019

Predictors of Extubation Readiness

- Lack of strong evidence to support their use
  - **Low accuracy**
  - No added benefits in the identification of **extubation failures** when compared to clinical judgment alone

- Larger and more standardized studies are needed

Shalish et al. ADC Fetal & Neonatal Ed, 2019

Predictors of Extubation Readiness

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- No single test can capture the complex nature of why infants fail extubation

- Every infant is different

PAST	PRESENT	FUTURE
Intuition Medicine	Evidence-based Medicine	Precision Medicine
Signs and Symptoms	Clinical Trials	Algorithms

- We need more complex, individualized tools that can capture more intrinsic biological variables …

Automated Prediction of EXtubation Readiness in Extremely Preterm Infants: The APEX Multicenter Study

McGill

APEX investigators:

Wissam Shalish, Lara Kanbar, Charles Onu, Lajos Kovacs, MD, Sanjay Chawla, MD, Martin Keszler, MD, Smita Rao, Karen Brown, MD, Doina Precup, PhD, Robert E Kearney, PhD and Guilherme M Sant'Anna, MD, PhD

Centre universitaire de santé McGill
McGill University Health Centre

Hôpital général juif
Jewish General Hospital

Children's Hospital of Michigan

DMC

DETROIT MEDICAL CENTER / WAYNE STATE UNIVERSITY

Women&Infants

Study Aim

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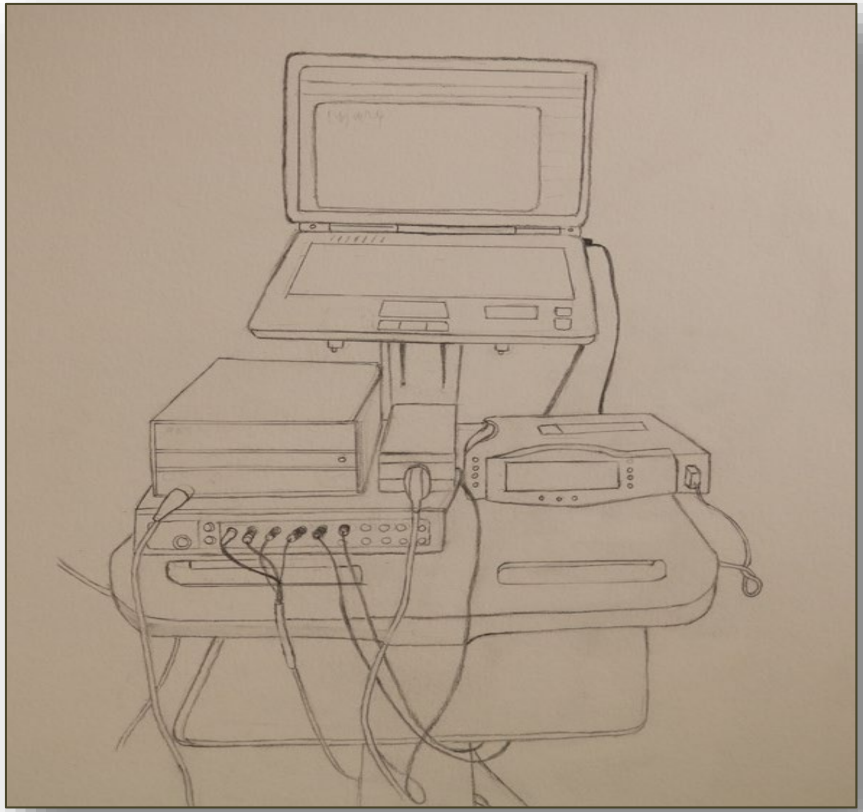
To develop an individualized, automated and objective predictor of extubation readiness using a combination of **clinical variables** and quantitative measures of **cardiorespiratory behavior**

Methods – Data Acquisition

Cardiorespiratory Data



Clinical Data

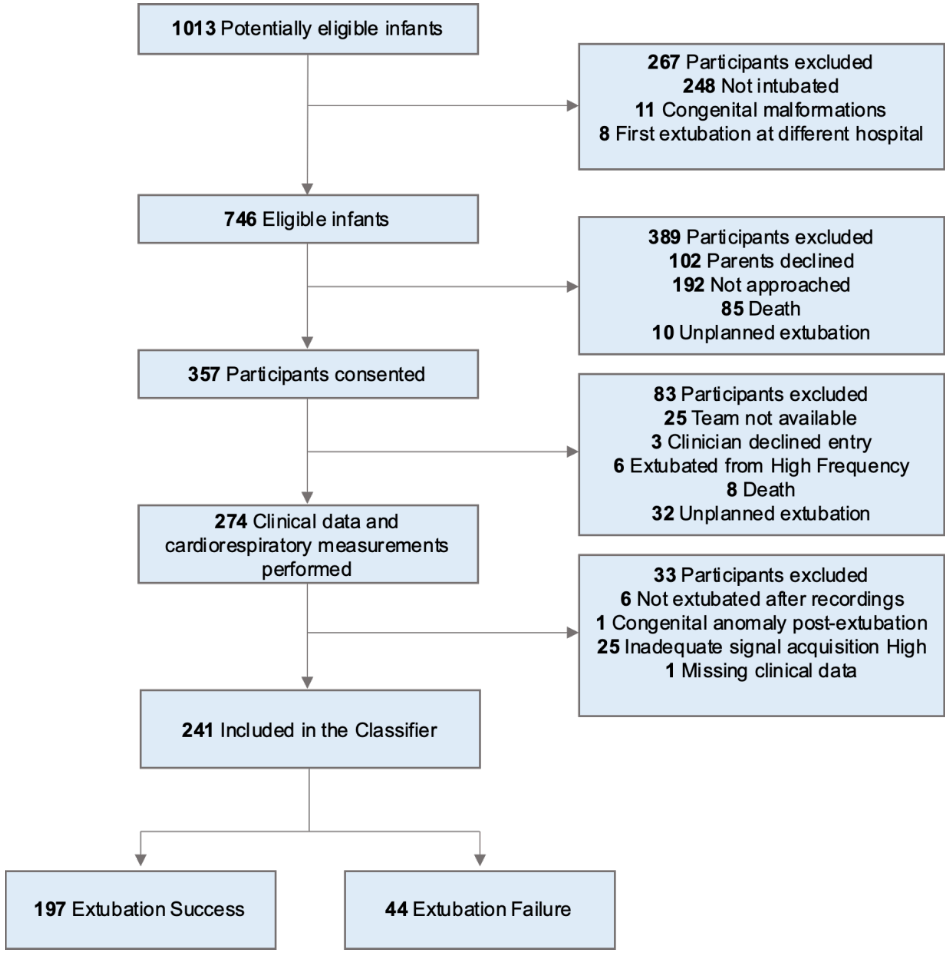
Demographic Data

- Gestational age, birth weight
- Delivery information
- Morbidities prior to extubation (PDA, NEC, infection, IVH…)

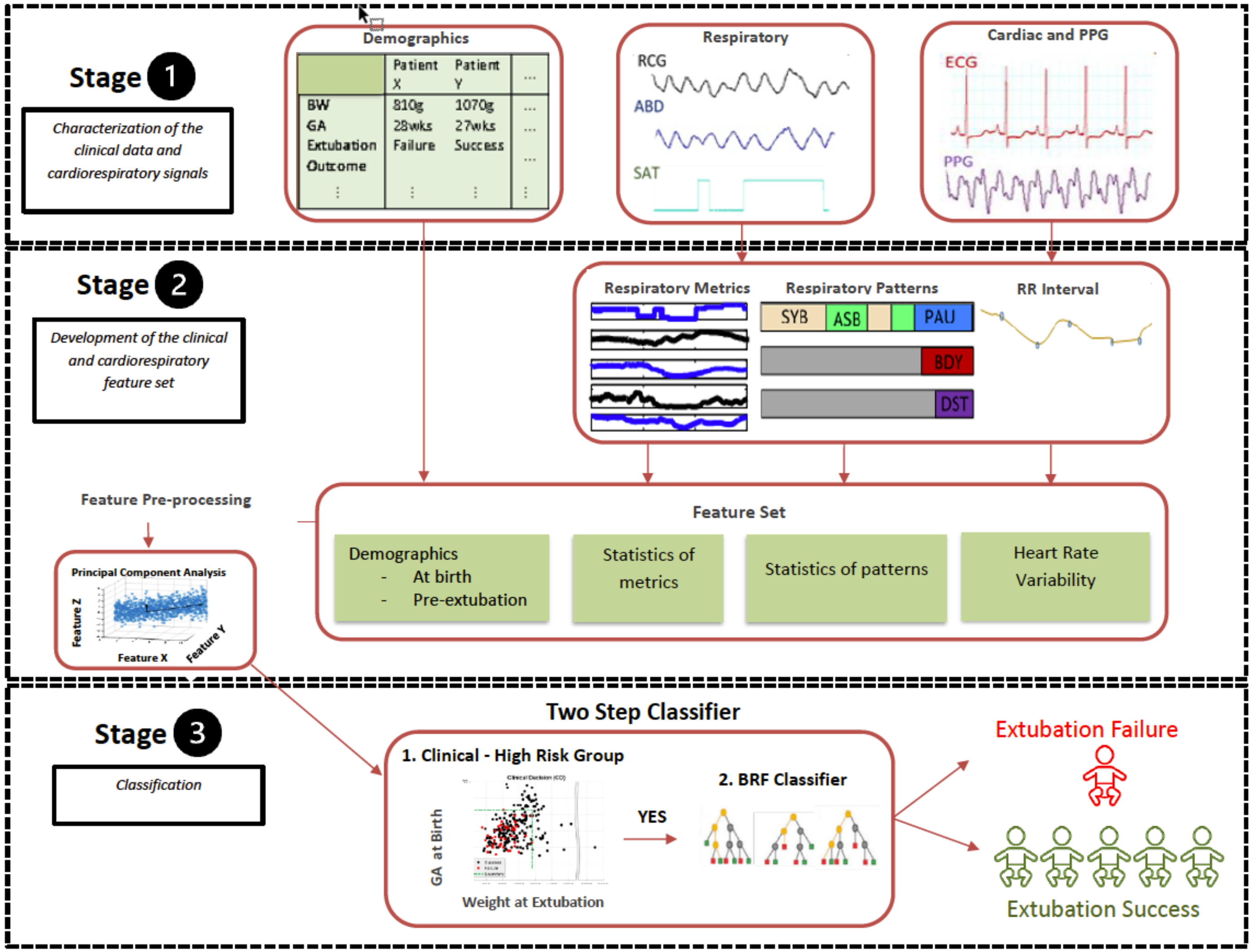
Immediately Pre-Extubation

- Postmenstrual age, weight
- Ventilator settings
- Blood gases

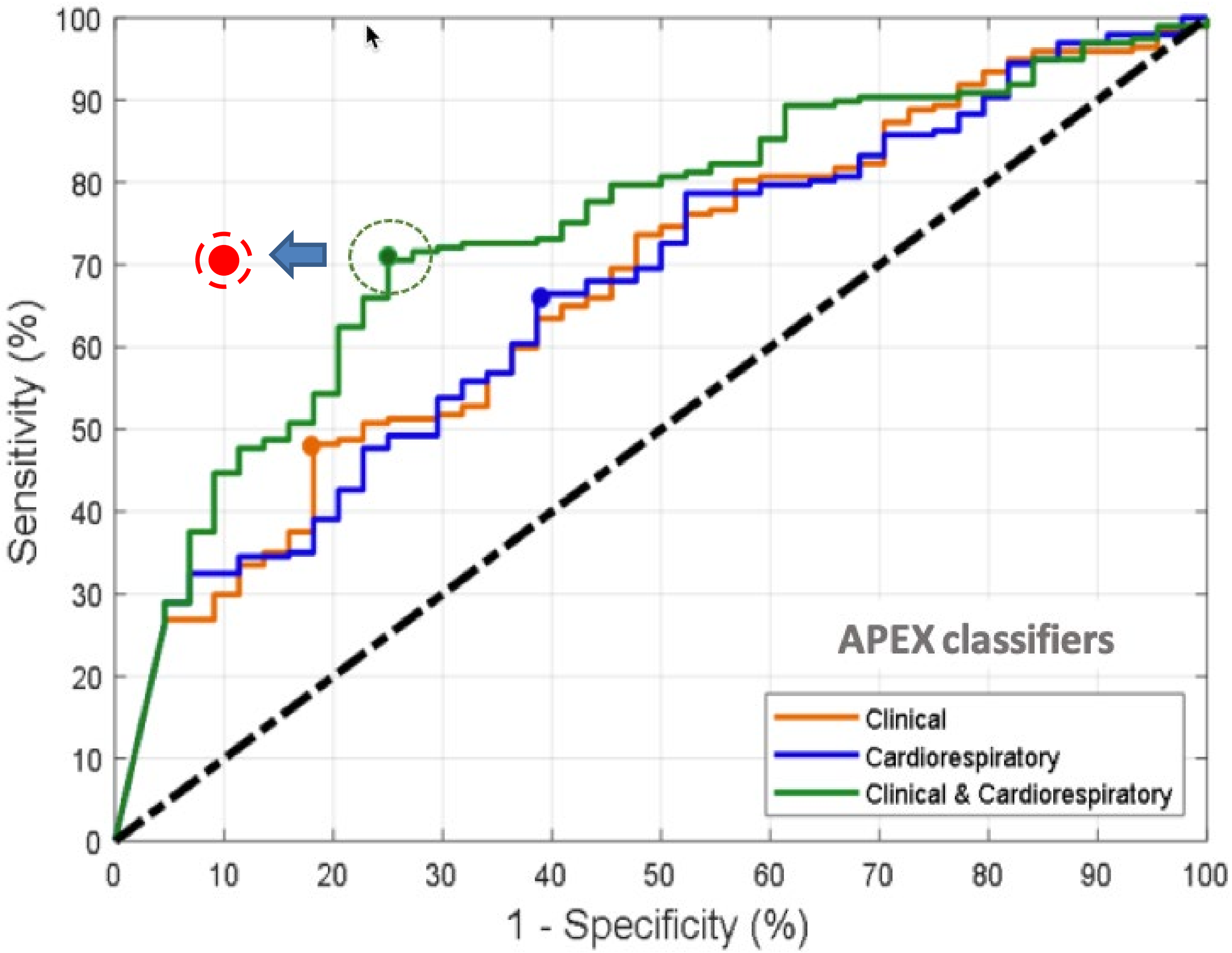
APEX Study



1013 Potentially eligible infants
267 Participants excluded
248 Not intubated
11 Congenital malformations
8 First extubation at different hospital
746 Eligible infants
389 Participants excluded
102 Parents declined
192 Not approached
85 Death
10 Unplanned extubation
357 Participants consented
83 Participants excluded
25 Team not available
3 Clinician declined entry
6 Extubated from High Frequency
8 Death
32 Unplanned extubation
274 Clinical data and cardiorespiratory measurements performed
33 Participants excluded
6 Not extubated after recordings
1 Congenital anomaly post-extubation
25 Inadequate signal acquisition High
1 Missing clinical data
241 Included in the Classifier
197 Extubation Success
44 Extubation Failure



Stage 1
Characterization of the clinical data and cardiorespiratory signals
Demographics
Patient X
Patient Y
BW
GA
Extubation Outcome
810g
28wks
Failure
1070g
27wks
Success
Respiratory
RCG
ABD
SAT
Cardiac and PPG
ECG
PPG
Stage 2
Development of the clinical and cardiorespiratory feature set
Respiratory Metrics
Respiratory Patterns
SYB
ASB
PAU
BDY
DST
RR Interval
Feature Pre-processing
Principal Component Analysis
Feature Z
Feature X
Feature Y
Feature Set
Demographics
- At birth
- Pre-extubation
Statistics of metrics
Statistics of patterns
Heart Rate Variability
Stage 3
Classification
Two Step Classifier
1. Clinical - High Risk Group
GA at Birth
Weight at Extubation
YES
2. BRF Classifier
Extubation Failure
Extubation Success



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Pediatric Research, 2022

Extubated Early (<7 days)

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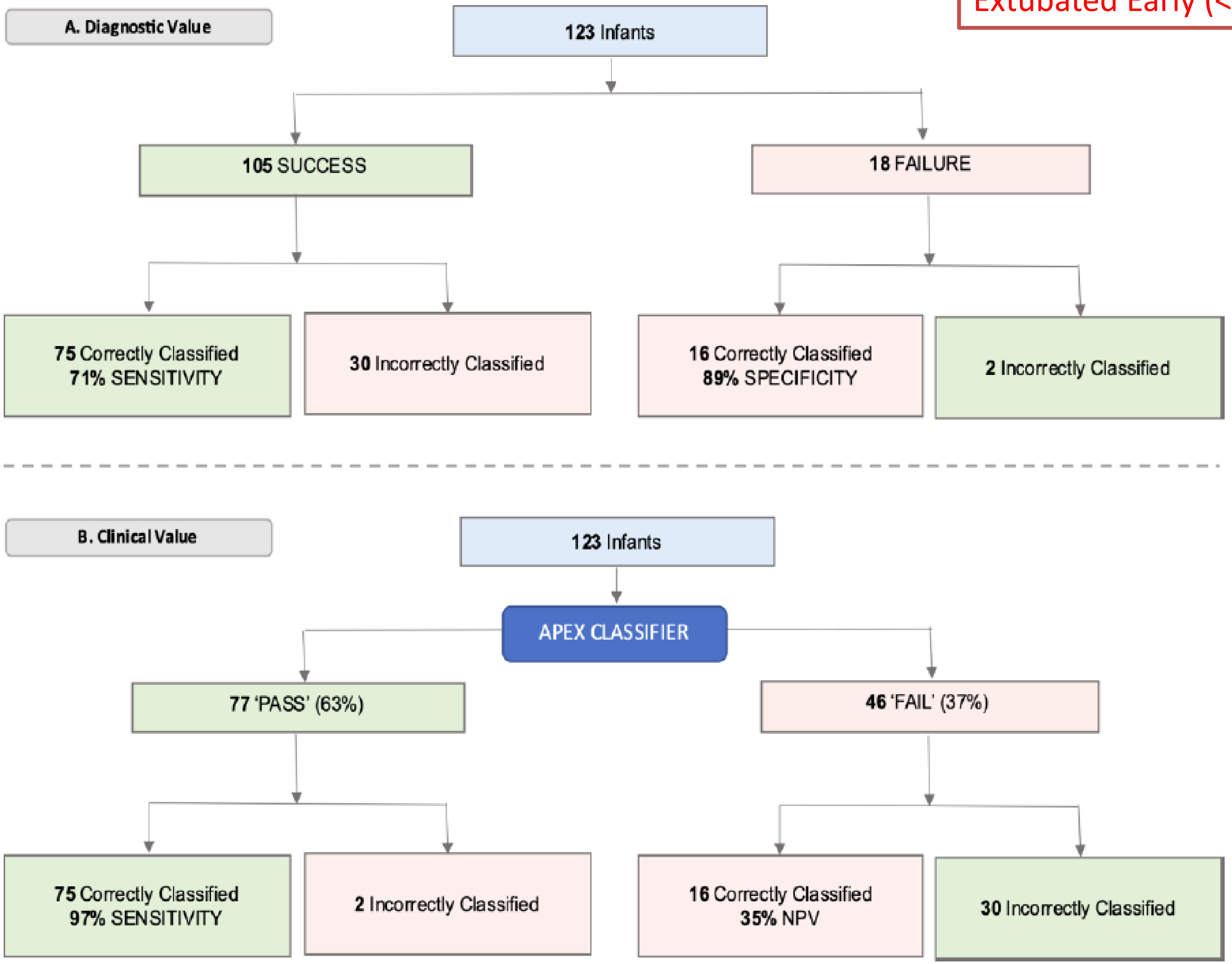

Pediatric Research, 2022

Conclusions

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- Many steps are necessary before adoption of this approach

- At an individualized level, we need to weigh the **costs of failure** against the **costs of keeping** the infant mechanically ventilated for a little longer

Pediatric Research, 2022

Costs of failure vs **Costs of keeping** the infant mechanically ventilated

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Table 2. Characteristics of the extubation groups

	Early Success (n=93)	Early Failure (n=36)	Late Success (n=59)	Late Failure (n=34)
Demographics				
GA, weeks	27.4 [26.3-28.8]*	26.3 [25.9-27.1]‡	25.4 [24.8-26.6]¥	24.6 [24.1-25.3]
BW, grams	1030 [870-1156]*	855 [760-975] ‡	740 [658-875] ¥	674 [590-730]
Male, %	47 (51)	22 (61)	31 (53)	17 (50)
SGA, %	10 (11)	5 (14)	5 (8)	3 (9)
ANS, %	83 (89)	30 (83)	53 (90)	32 (94)
C-section, %	59 (63)	24 (67)	45 (76)	18 (53)
Chorio, %	38/74 (51)	14/30 (47)	26/51 (51)	17/28 (61)
Apgar 5 min[a]	7 [5-8]	8 [6-8]	6 [5-8]	6 [4-7]
Intubation 1st hour, %	59 (63)	29 (81)	51 (86)	29 (85)

J Pediatrics, 2022

Costs of failure vs **Costs of keeping** the infant mechanically ventilated

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Table 4. Respiratory morbidities and outcomes at discharge per extubation group

	Early Success (n=93)	Early Failure (n=36)	Late Success (n=59)	Late Failure (n=34)
Respiratory morbidities				
Death/BPD, %	29 (31)*	30 (83)	39 (66)¥	31 (91)
BPD, %	26/90 (29)*	26/32 (81)	39 (66)¥	30/33 (91)
Death, %	3 (3)	4 (11) ‡	0 (0)	1 (3)
MV, days	3 [1-5]*	22 [10-32]	26 [18-31]¥	38 [33-42]
Any RS, days	45 [31-58]*	64 [41-82]	71 [60-82]¥	85 [76-102]
O_2, days	15 [2-43]*	76 [25-98]	47 [23-82]¥	93 [70-106]

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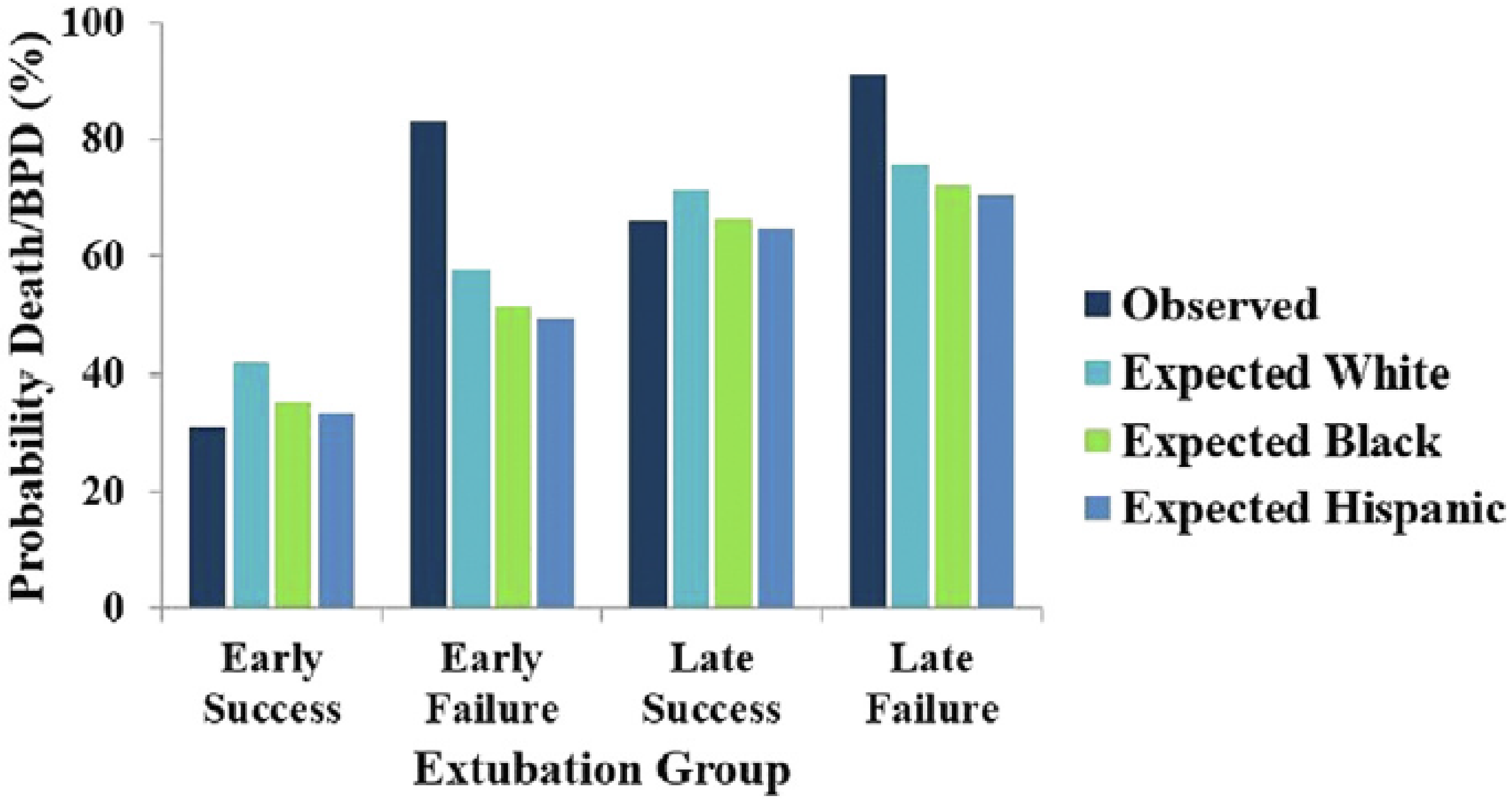


	Observed-to-Expected Death/BPD Standardized Ratios (95% Confidence Intervals)			
Race/Ethnicity	Early Success	Early Failure	Late Success	Late Failure
White	0.74 (0.47, 1.01)	1.44 (0.93, 1.96)	0.93 (0.64, 1.22)	1.2 (0.78, 1.63)
Black	0.88 (0.56, 1.2)	1.61 (1.04, 2.19)	1 (0.68, 1.31)	1.26 (0.82, 1.71)
Hispanic	0.93 (0.59, 1.26)	1.69 (1.09, 2.3)	1.02 (0.7, 1.34)	1.3 (0.84, 1.75)

J Pediatrics, 2022

EDITORIAL VIEWS

Extubation, Black Boxes, and Ontology

Martin J. Tobin, M.D., Franco Laghi, M.D.

Extubation and the Myth of "Minimal Ventilator Settings"

"**The challenge of medicine** is not about taking care of most patients who do well irrespective of the methods employed. Instead, the goal is to take feasible steps that have a high likelihood of **avoiding undesirable outcomes in a small number of instances**"

"Actually, it is to take data generated in groups of patients and determine **how to best apply the information in the single patient** being managed at a given moment in time"

L'Hôpital de Montréal pour enfants
The Montreal Children's Hospital
Centre universitaire de santé McGill
McGill University Health Centre

AJRCCM, 2012
Anesthesia, 2017

Precision Medicine → Neonatal Respiratory Care

- The challenge is to find the **right indication and timing** for invasive and noninvasive support during the respiratory course of **each infant**

Bancalari E, NEJM, 2017

The Evolution of Patient Diagnosis

From Art to Science

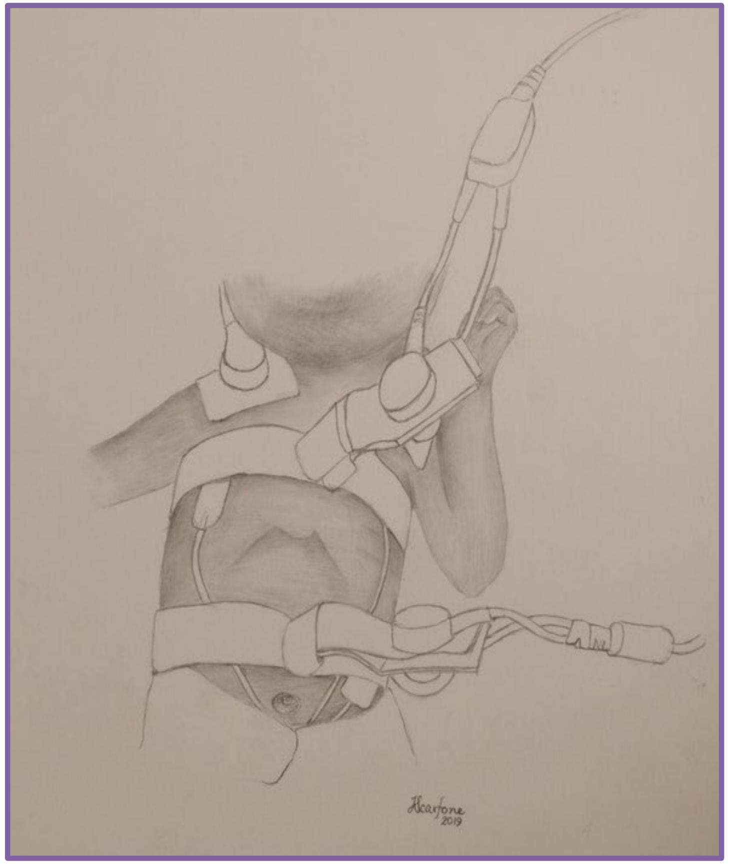
- Patients are diagnosed based on **history, clinical exam and laboratory reports** that are interpreted considering clinical experience and the medical literature

ARTIFICAL INTELIGENCE now bring insight from population-level data to individual care

Mandl K and Bourgeois F, JAMA Oct 2017
PrecisionLink initiative at Boston Children's Hospital

Future Directions

- Instrumentation for data acquisition more user-friendly - wireless



ARTICLES

https://doi.org/10.1038/s41591-020-0792-9

nature medicine

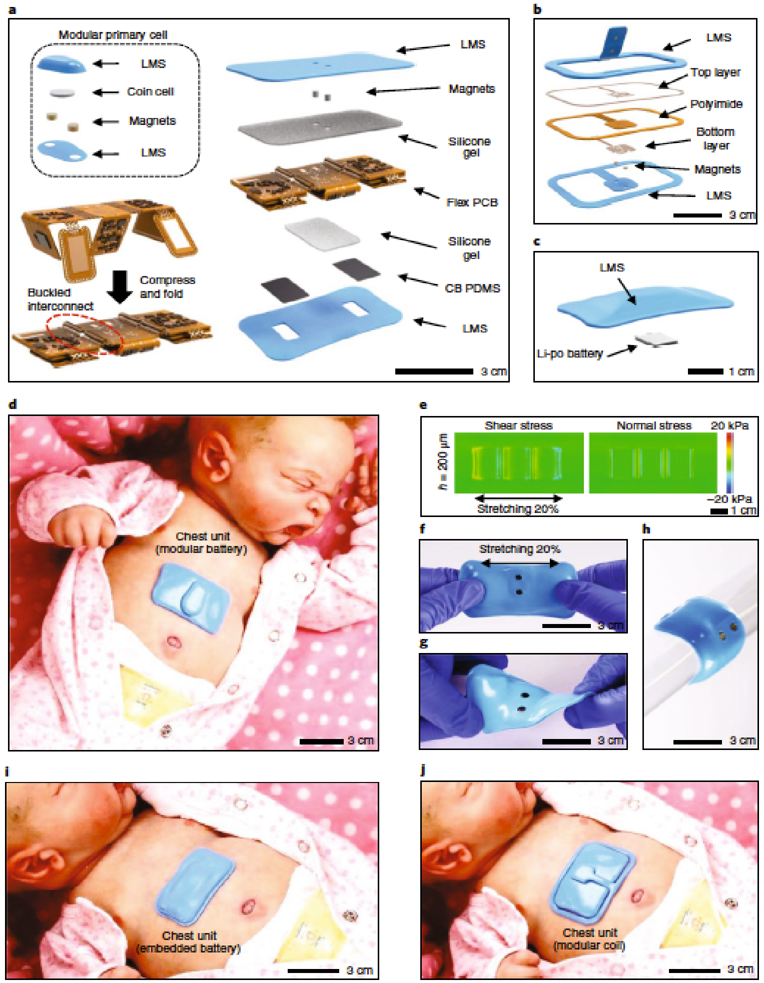
Check for updates

Skin-interfaced biosensors for advanced wireless physiological monitoring in neonatal and pediatric intensive-care units

Wearable wireless multimodal patch sensors, to measure the respiratory frequency

Future Directions

- Instrumentation for data acquisition more user-friendly - wireless



Wearable wireless multimodal patch sensors, to measure the respiratory frequency

Future Directions

- Develop prediction models to prevent failures with the highest risk

- At an individualized level, we need to weigh the **costs of failure** against the **costs of keeping** the infant mechanically ventilated for a little longer

Extubation Failure - Recommendation

McGill

- In the meantime, neonatal clinicians still must decide what **clinical actions should be taken at different levels of risk,** understanding the possible outcomes of any decision

- In the end, any decision or predictor will require that we **accept and manage the certainty of uncertainty**

Take Home Messages

- Currently, neonatologists are invasively ventilating smaller and more immature infants
- The decision concerning best time for extubation is difficult since both **prolonged MV** and **multiple reintubations** are undesirable outcomes
- Accurate bedside **predictors of extubation readiness** in extremely preterm infants are needed

Take Home Messages

McGill

- The extubation equation is quite complex!
- Infants are reintubated at highly variable time frames and for diverse etiologies
- BOTH **Early AND Successful** extubations are associated with the most favorable outcomes

Review

Decision to extubate extremely preterm infants: art, science or gamble?

Wissam Shalish [1], Martin Keszler [2], Peter G Davis [3], Guilherme M Sant'Anna [1]

- Shalish W, et al. Arch Dis Child Fetal Neonatal Ed 2021;0:F1–F8.

Box 1 Causes of reintubation in extremely preterm infants

Decreased respiratory drive/Central apnoeas

- Immature respiratory control centres
- Infection/Infection/Necrotising enterocolitis
- Decreased O_2 delivery (hypoxia, shock, anaemia)
- Intraventricular haemorrhage (during the acute process)
- Thermal instability
- Metabolic derangements (eg, hypoglycaemia)

Upper airway obstruction/Obstructive apnoeas

- Airway oedema (especially postextubation)
- Airway inflammation (eg, from gastro-oesophageal reflux)
- Airway secretions/Mucus plugs
- Vocal cord injuries
- Subglottic stenosis

Pulmonary causes

- Immature lung parenchyma
- Atelectasis/Lung collapse
- Low functional residual capacity (eg, from abdominal distension)
- Pulmonary overcirculation/Haemorrhage
- Lung inflammation
- Surfactant deficiency or dysfunction
- New-onset air leak syndrome (eg, pneumothorax)
- Diaphragmatic weakness/Fatigue

Suboptimal provision of non-invasive respiratory support

- Inadequate nasal prongs or mask size
- Excessive interface leak
- Inadequate clearance of airway secretions
- Suboptimal positioning (eg, excessive neck flexion or extension)

Box 2 Recommendations for standardised reporting of extubation outcomes

1. Definition of extubation failure:
   a. Define based on reintubation rather than fulfilment of clinical criteria.
   b. Ideally, provide (or mandate) participating units with reintubation guidelines.
   c. If possible, track compliance to the proposed guidelines.
2. Reporting of extubation failure rates:
   a. *Clinical practice and research:* at 48–72 hours and at 7 days postextubation.
   b. *For randomised controlled trials:* present reintubation rates of control and intervention groups using cumulative distribution curves for the first 7 days postextubation and compare extubation outcomes using time-to-event methodology.
3. Causes for each reintubation:
   a. Specify if a non-respiratory-related cause was identified (eg, confirmed infection or necrotising enterocolitis).
   b. Specify the most important reasons for reintubation (eg, apnoeas and bradycardias, increased work of breathing, increased O_2 needs).
4. Report serious adverse events that occur in the 24 hours following extubation:
   a. Serious adverse events should include haemodynamic instability (chest compressions, inotropic support), severe or prolonged hypoxia, pneumothorax, pulmonary haemorrhage, necrotising enterocolitis, severe intraventricular haemorrhage and death.

Box 3 Recommendations for optimising weaning and assessment of extubation readiness in clinical practice

1. Routine and proactive assessment of extubation potential:
   a. Discuss as a multidisciplinary team during rounds.
   b. Infants should not be kept intubated solely based on their age or weight.
2. Strategies to expedite weaning and reduce mechanical ventilation duration:
   a. Optimise nutrition and fluid management.
   b. Optimise caffeine maintenance dose in cases of inconsistent respiratory drive.
   c. Consider postnatal steroids.
   d. Wean or cease sedation.
   e. Develop and implement respiratory therapist and/or nursing-driven weaning protocols.
3. Parameters to consider extubation (at any time point during the day or night) on conventional or high frequency oscillatory ventilation:
   a. Mean airway pressure: 6–8 cm H_2O.
   b. Fraction of inspired oxygen: 0.21–0.30.
   c. Peak inflation pressure (preset on pressure-controlled ventilation or achieved during volume-controlled ventilation): 12–15 cm H_2O.
   d. pH prior to extubation: 7.3–7.4.
4. Spontaneous breathing trials or any other extubation readiness trial are not advised.

These recommendations only apply to extremely preterm infants undergoing their first planned extubation attempt during the first 4 weeks of life.

Disclosure

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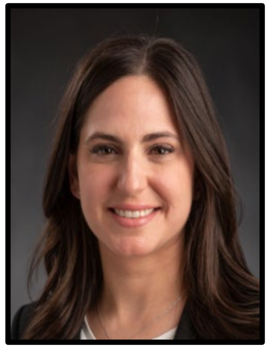

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Obrigado / Gracias

Thanks

Successful transition