# PROLONGED WEANING

# INTRODUCTION

# WEANING PROCESS

- ONE OF THE MOST CHALLENGING TOPIC
- STUDIED SINCE 70’S & 80’S
- CONSIDERABLE WORLDWIDE VARIATION IN WEANING PRACTICES
- NOT MANY GUIDELINES

# WEANING CLASSIFICATION:

## ONCE A PATIENT IS INTUBATED, WE DO CONTINUOUS WORK TO GET RID OF PROBLEMS TO AIM AT EXTUBATION

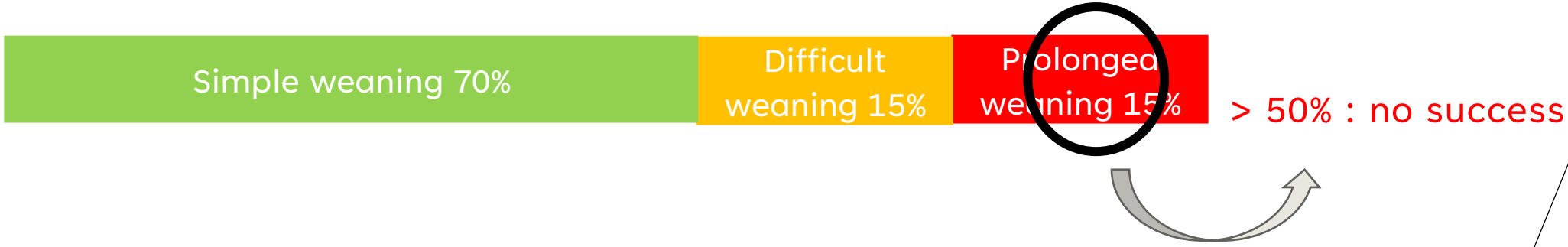
- Simple Weaning – successful extubation on the first attempt without difficulty. 70%
- Difficult Weaning – failed on the initial attempt and require up to 7 days to achieve successful extubation, 15%
- Prolonged Weaning - > 7 days to discontinue invasive ventilation from the first attempt, 15%


GOAL:
Extubation !!

(Neeraj M Shah et al., Prolonged weaning from mechanical ventilation; Who, What, When, and How?, 2024)

# PROLONGED MECHANICAL VENTILATION (MV)

- 15% of all MV patients need prolonged ventilator care and the rate will continue to rise
- > 21days : Poor prognosis with 2-year mortality 25%
- > 50% of patients who didn't succeed weaning in ICU will be liberated from MV in the post acute setting




*(Tamas Dolinay, et al. Ventilator Weaning in Prolonged Mechanical Ventilation – A Narrative Review, 2024)*

# TRACHEOSTOMY :

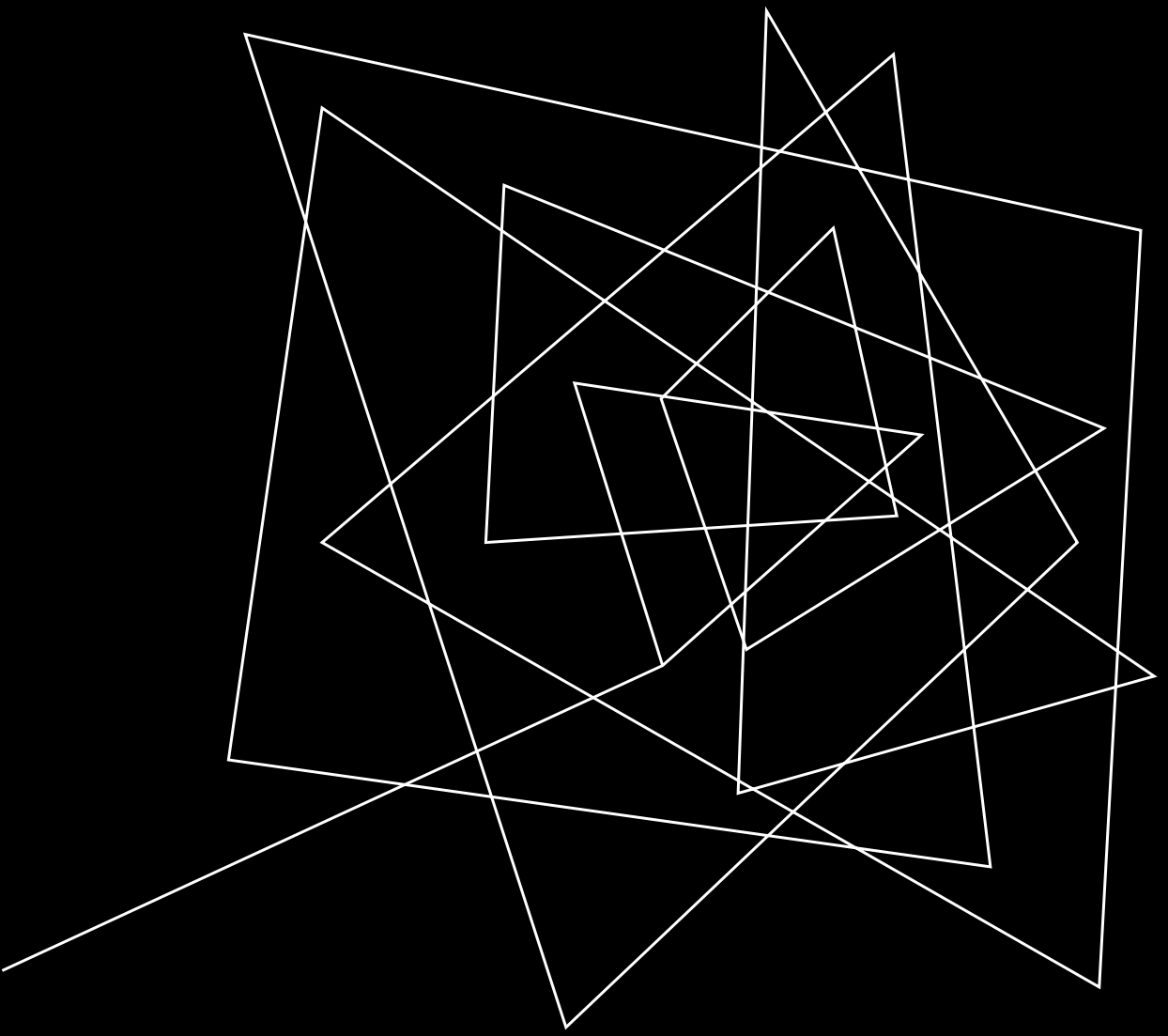
- 8 % of all MV patients undergo tracheostomy; improvement of physiology.
- The timing remains controversial
- Early tracheostomy could result in more ventilator-free days, but not necessarily survival
- Cuff off → Speaking valve w/ vent and w/o vent → T capped → Decannulation

(Tamas Dolinay et al., Ventilator Weaning in Prolonged Mechanical Ventilation – A narrative Review, 2024)

# COST :

- Patients > 3 weeks on MV, three times more cost in a hospital than non ventilator patients
- Uses > 1/3 ICU budget

(Tamas Dolinay et al., Ventilator Weaning in Prolonged Mechanical Ventilation – A narrative Review, 2024)



# CAUSES AND PATHOPHYSIOLOGY OF WEANING FAILURE

# CAUSES OF DIFFICULT WEANING

- Disease-imposed factors

  -- Reversible factors??

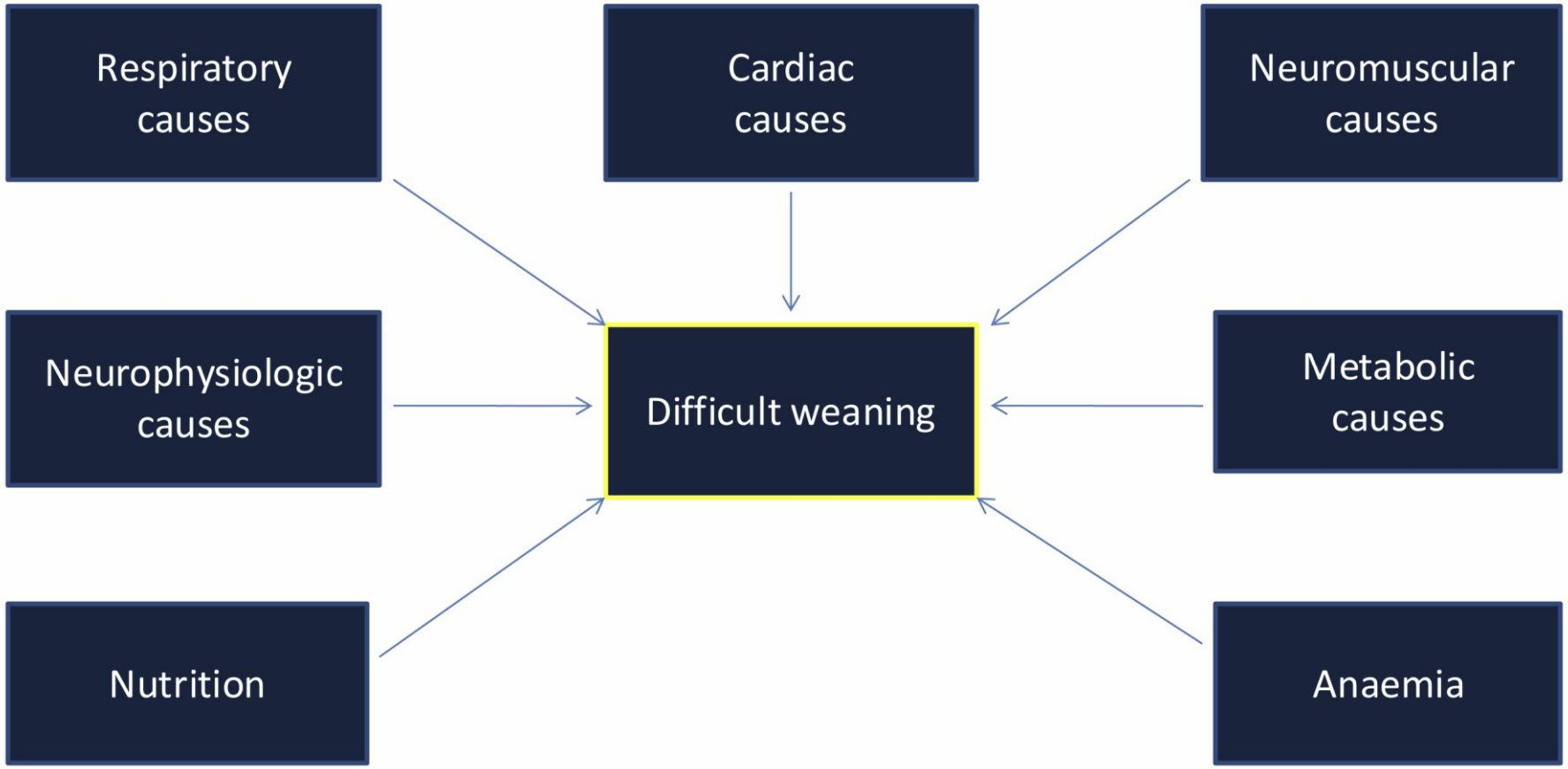
- Clinician-imposed factors

  -- Clinician delay in recognizing the ability of a patient

  -- Inappropriate ventilator setting; overload / underload, blocking recovery

# CAUSES OF DIFFICULT WEANING

→ AGGRESSIVELY SEEK & TREAT REVERSIBLE CAUSES



Respiratory Causes

# RESPIRATORY CAUSES

Medical History

## Medical History (Background) to set up goal & expectation

1. **Any Lung issues?**

COPD, Asthma, ARDS, Lung CA, Pulmonary fibrosis, PNA, etc

2. **Any Other organs?**

Heart, Brain, Kidney, Liver, etc..

3. **How about Irreversible factors?**

Neuromuscular and chest wall disorders?

3. **Anything else?**

Obesity, Drug user, Psychiatric issues?

Respiratory Causes

# RESPIRATORY CAUSES

Ventilation Demand

## How is Ventilation Demand? The Demand is increasing??

**If so, what causes that??**

Hypoxemia?

Dead Space increased?

Excess CO2 production? (metabolic status changed?)

Metabolic Acidosis?

Neuropsychiatric factors?

(Leo M Heunks, et al. Clinical review: The ABC of weaning failure a structured approach, 2010)

Respiratory Causes

# RESPIRATORY CAUSES

Ventilation Drive

## How is Ventilation Drive? The Drive is decreasing??

**If so, what causes that??**

Excessive sedation ?

Metabolic alkalosis ?

Central Nervous System Disease ?

Central Sleep Apnea ?

Obese Hypoventilation Syndrome ?

(Leo M Heunks, et al. Clinical review: The ABC of weaning failure a structured approach, 2010)

Respiratory Causes

# RESPIRATORY CAUSES

Airway Resistance

## How is Airway Resistance? Raw is increasing??

**If so, what causes that??**

Artificial Airway ? → Consideration of ET/trach tube size

Secretion/Mucus Plug ? → Humidification, Suctioning, Bronchoscopy

Bronchospasm ? → Bronchodilator

Bronchial Wall Edema ? → ARDS, Auto PEEP → Adjust E time/PEEP

(Leo M Heunks, et al. Clinical review: The ABC of weaning failure a structured approach, 2010)

Respiratory Causes

# RESPIRATORY CAUSES

Lung Compliance

## How is Lung Compliance? Compliance is decreasing??

**If so, what causes that??**

| | |
|---|---|
| Chest Wall | Edema, Increased Abdominal Pressure, Pleural Effusion, Obesity |
| Lung | Auto PEEP, Alveolar filling, PNA, Interstitial lung disease/fibrosis |

Set up PEEP to make Ptrans > 0

Thoracentesis

Diuretics

Suction/Bronchoscopy

(Leo M Heunks, et al. Clinical review: The ABC of weaning failure a structured approach, 2010)

CIDW

# RESPIRATORY CAUSES

## Critical illness-associated diaphragmatic weakness (CIDW)

A progressive decline in diaphragm performance resulting from mechanical ventilation, systemic inflammation, and direct effects on the phrenic nerve

Pathophysiology

Underuse (Disuse Atrophy) → Leads to Atrophy

Overuse (Excessive Inspiratory Effort) → Causes Injury (VILI)

- 60-80% of mechanically ventilated ICU patients;
- Ventilator-Induced Diaphragm Dysfunction (VIDD); diaphragm thinner and fibrosis
- Strongly correlates with prolonged ventilation & weaning failure

Valentine Le Stang, et al., Critical illness-associated limb and diaphragmatic weakness, 2024

Respiratory Causes

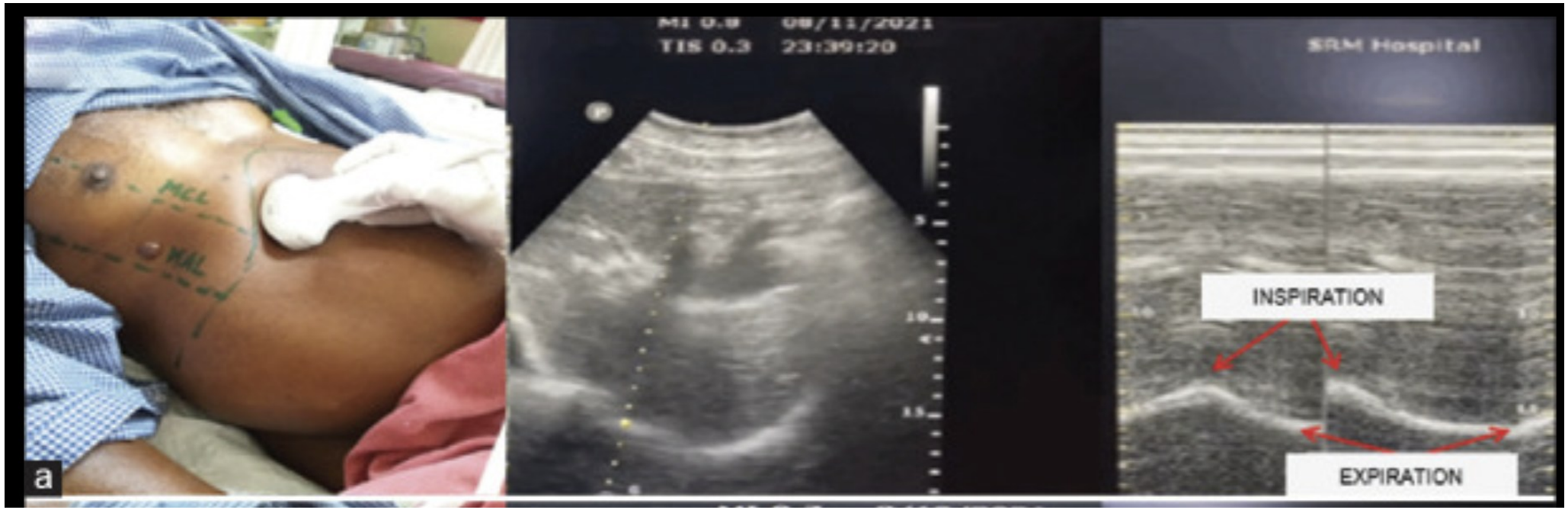
# HOW TO ASSESS CIDW ?

CIDW

Ravi Saravanan, et al. Role of diaphragm ultrasound in weaning mechanically ventilated patients. 2022

## Ultrasound (Diaphragm Imaging)

Promising bedside, noninvasive real time monitor




Diaphragm Excursion (DE) DE < 1.2cm High risk

Respiratory Causes

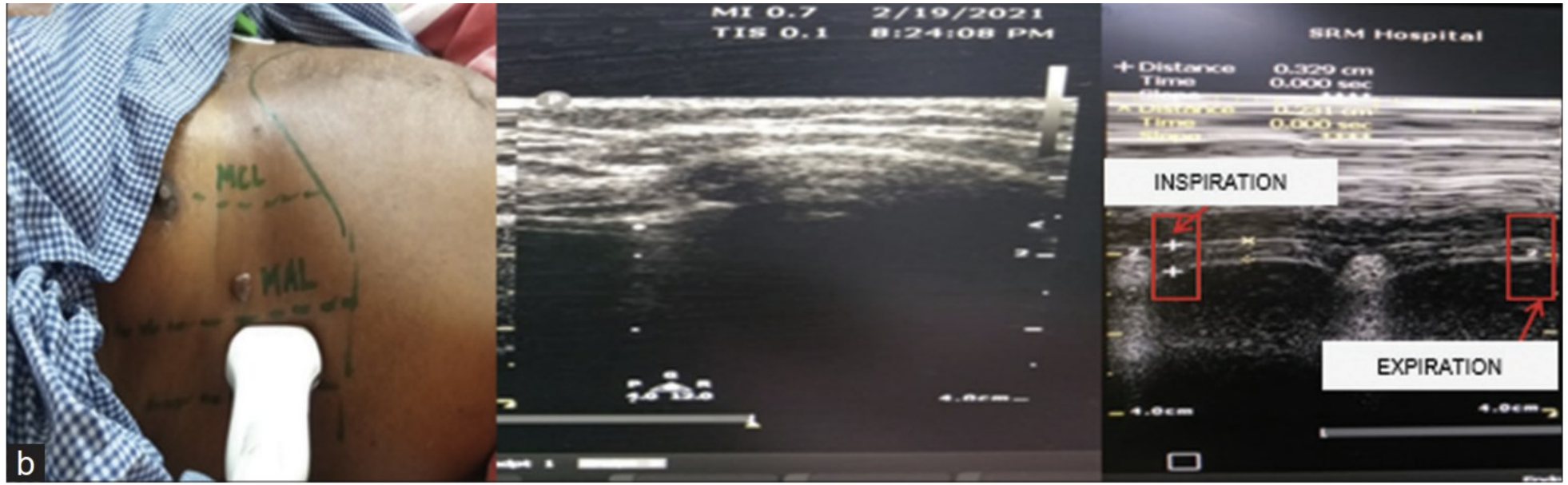
# HOW TO ASSESS CIDW ?

CIDW

Ravi Saravanan, et al. Role of diaphragm ultrasound in weaning mechanically ventilated patients. 2022

## Ultrasound (Diaphragm Imaging)

Promising bedside, noninvasive real time monitor

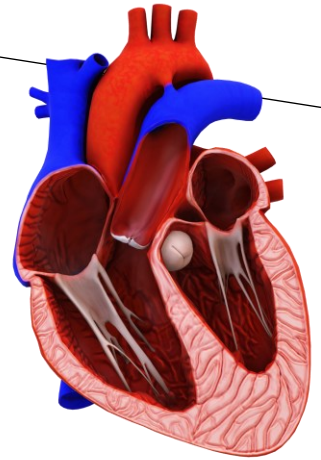



Diaphragm Thickening Fraction (TF) TF=(TDmax-TDmin)/TDmin *100

TF > 30% normal, if <20% suggest dysfunction

Cardiac Causes

# CARDIAC CAUSES



**Important contributor to weaning failure**
(Christina Routsi, Weaning failure of cardiovascular origin, 2019)

**“Weaning-Induced” cardiac failure** was introduced in 2002.

Weaning failure resulted from congestive heart failure are common especially among **COPD/underlying cardiac disease**.

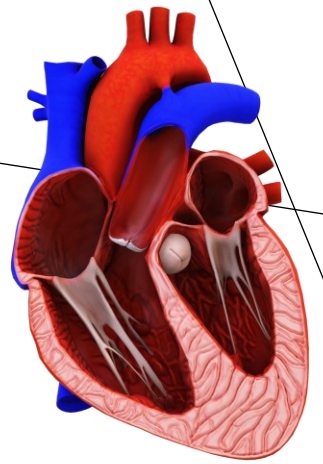
Weaning failure was more frequently due to varying degrees of LV diastolic than systolic dysfunction

The success of weaning depends on the ability of respiratory system and cardiac pump to tolerate these changes

Cardiac Causes

(Christina Routsi, Weaning failure of cardiovascular origin, 2019)

# CARDIAC CAUSES



**Weaning induced pulmonary edema**

SBT; negative intrathoracic pressure

Venous return pressure ingredient ↑

RV preload ↑
Central Blood Volume
LV preload

Surrounding pressure of LV ↑
LV afterload

WOB ↑

Adrenergic tone ↑

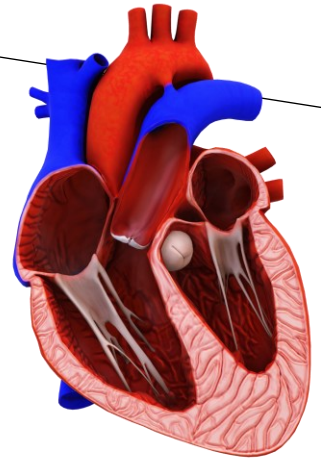
PA occlusion pressure ↑

LV filling pressure ↑

Pulmonary Edema

Cardiac Causes

# CARDIAC CAUSES



**Important contributor to weaning failure**

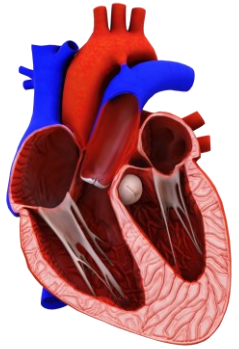
Early identification of high-risk cardiovascular origin & Accurate diagnosis are crucial

Until appropriate evidence emerges, tailoring cardiovascular treatment & monitoring the individual responses to therapy should be carefully performed

# CARDIAC CAUSES

Suspected weaning failure of cardiovascular origin

Predisposing risk factors, cardiovascular/pulmonary
Exclude others



Assessment :
TTE (transthoracic echocardiography)
Chest Ultrasound
BNP(Brain Natriuretic Peptide)
SvO2
PA catheter
Coronary angiography, etc

Combine different techniques, assess before / during SBT

Confirmed weaning failure of cardiovascular origin
Determine etiology and start appropriate treatment

# CARDIAC CAUSES TREATMENT

Cardiac Causes

**Systolic LV dysfunction**

Fluid removal guided by BNP

Consider Inotropic Agents

**Diastolic LV dysfunction**

Fluid removal guided by BNP

Treat HTN

Treat myocardial ischemia

Treat tachycardia

**Coronary disease**

Vasodilator, antiplatelets

If no improvement, consider coronary reperfusion

(Christina Routsi, Weaning failure of cardiovascular origin, 2019)

# CARDIAC CAUSES TREATMENT

Cardiac Causes

COPD w HTN during SBT

Consider Nitrates

Consider Calcium channel blockers

Hyper-trophic cardiomyo pathy

Beta-blockers

Calcium channel blockers

(Christina Routsi, Weaning failure of cardiovascular origin, 2019)

# PSYCHOLOGICAL CAUSES :

Psychological Causes

- Up to 40% of patients who went through weaning
- Symptoms such as anxiety, fear, delirium
- Delirium; twice as likely to be difficult to wean
- No studies investigating psychological interventions in the prolonged weaning population
- Historical data demonstrating biofeedback techniques interventions....some benefits???

(Neeraj M Shah et al., Prolonged weaning from mechanical ventilation; Who, What, When, and How?, 2024)

# NUTRITIONAL CAUSES :

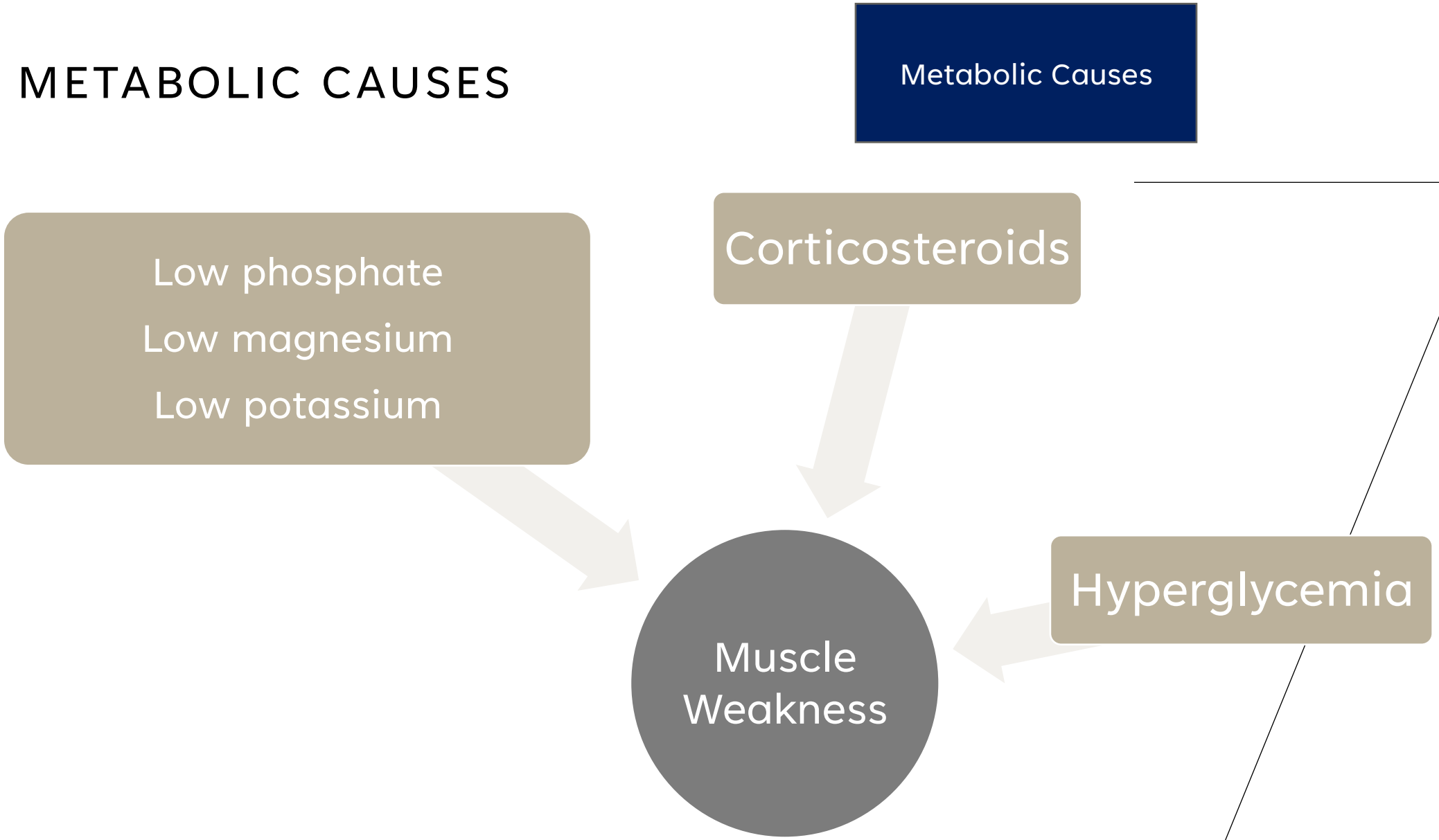
Nutritional Causes

- Optimal nutrition strategy remains unclear on MV patients
- Malnutrition exacerbates muscle wasting and delays recovery
- Protein intake $\geq$ 1.2-2.0 g/kg/day may help to prevent muscle loss per ESPEN guidelines for ICU Nutrition
- Nutritional optimization is crucial ; paired w rehab

Under or Over – feeding ??

(Neeraj M Shah et al., Prolonged weaning from mechanical ventilation; Who, What, When, and How?, 2024)

# METABOLIC CAUSES



Tailored Treatment Strategy !!

AGGRESSIVELY SEEK & TREAT REVERSIBLE CAUSES !!

# RISK OF PROLONGED WEANING:

- Infection such as VAP
- Ventilator-induced Lung Injury (VILI)
- Need for sedation and associated complication
- Airway trauma from prolonged intubation
- Deconditioning
- Cost

(Neeraj M Shah et al., Prolonged weaning from mechanical ventilation; Who, What, When, and How?, 2024)

# MINIMIZE RISK OF VAP:

- One of the most common causes of prolonged weaning; length of stay and mortality
- To reduce the risk;
  -- use of subglottic secretion drainage
  -- nursing in the semi-fowler >30 degrees
  -- minimizing sedation use
  -- oral care chlorhexidine rinse and mechanical cleaning
  -- maintain respiratory muscle for secretion clearance
  -- early tracheostomy

(Neeraj M Shah et al., Prolonged weaning from mechanical ventilation; Who, What, When, and How?, 2024)

# KEY FACTORS FOR SBT READINESS:

- **Improved** initial insult of **respiratory failure**
- Adequate **cough**
- Absence of excessive **secretion**
- Stable **cardiovascular** status
- Stable **metabolic** status
- Adequate **oxygenation**
- Stable **ventilation** – rate, Vt, PS, WOB, no significant respiratory acidosis
- Adequate **mentation**

(Neeraj M Shah et al., Prolonged weaning from mechanical ventilation; Who, What, When, and How?, 2024)

# WEANING GUIDELINE

AN OFFICIAL ATS/ACCP CLINICAL PRACTICE GUIDELINE, 2017

# GUIDELINE

## Pressure Augumentation during SBT

(moderate quality)

Initial SBT should be conducted with inspiratory pressure augmentation (5-8 cm H2O) rather than without (T piece or CPAP )for acute hospitalized patients ventilated >24hrs

## Ventilator Liberation Protocols

(low quality)

Acute hospitalized patients on vent > 24hrs should be managed with ventilator liberation protocol rather than no protocol

## Preventative Noninvasive Ventilation after Extubation

For patients on the vent >24 hrs and high risk of extubation but passed SBT, recommend NIV after extubation

*(Eddy Fan etal., Liberation from Mechanical Ventilation in Critically ill adults, An official ATS/ACCP Clinical Practice Guideline, 2017)*

GUIDELINE

## Early Mobility

For acute patients on vent >24hrs, protocolized rehabilitation directed toward early mobilization is recommended

## Sedation Liberation Protocols

Acute hospitalized patients on vent > 24hrs should be managed with protocol that attempt to minimize sedation

## Cuff Leak Test and Systemic Steroids

Recommend cuff leak test for patients meet extubation criteria but considered high risk for postextubation stridor

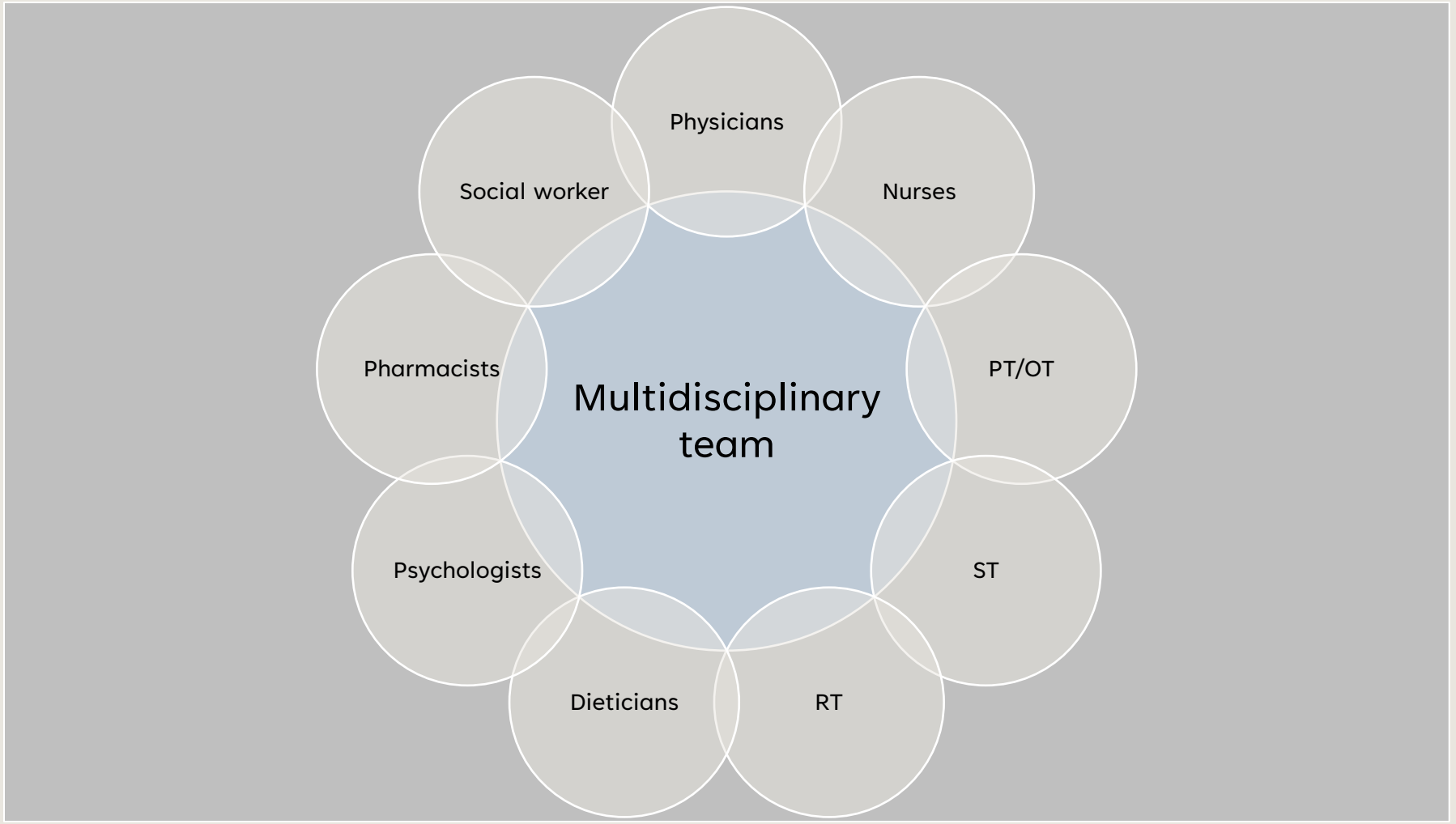
Recommend administering systemic steroids for at least 4 hrs before extubation for patients who have failed cuff leak test but otherwise being ready for extubation

*(Eddy Fan etal., Liberation from Mechanical Ventilation in Critically ill adults, An official ATS/ACCP Clinical Practice Guideline, 2017)*

# MANAGEMENT STRATEGIES FOR PROLONGED WEANING

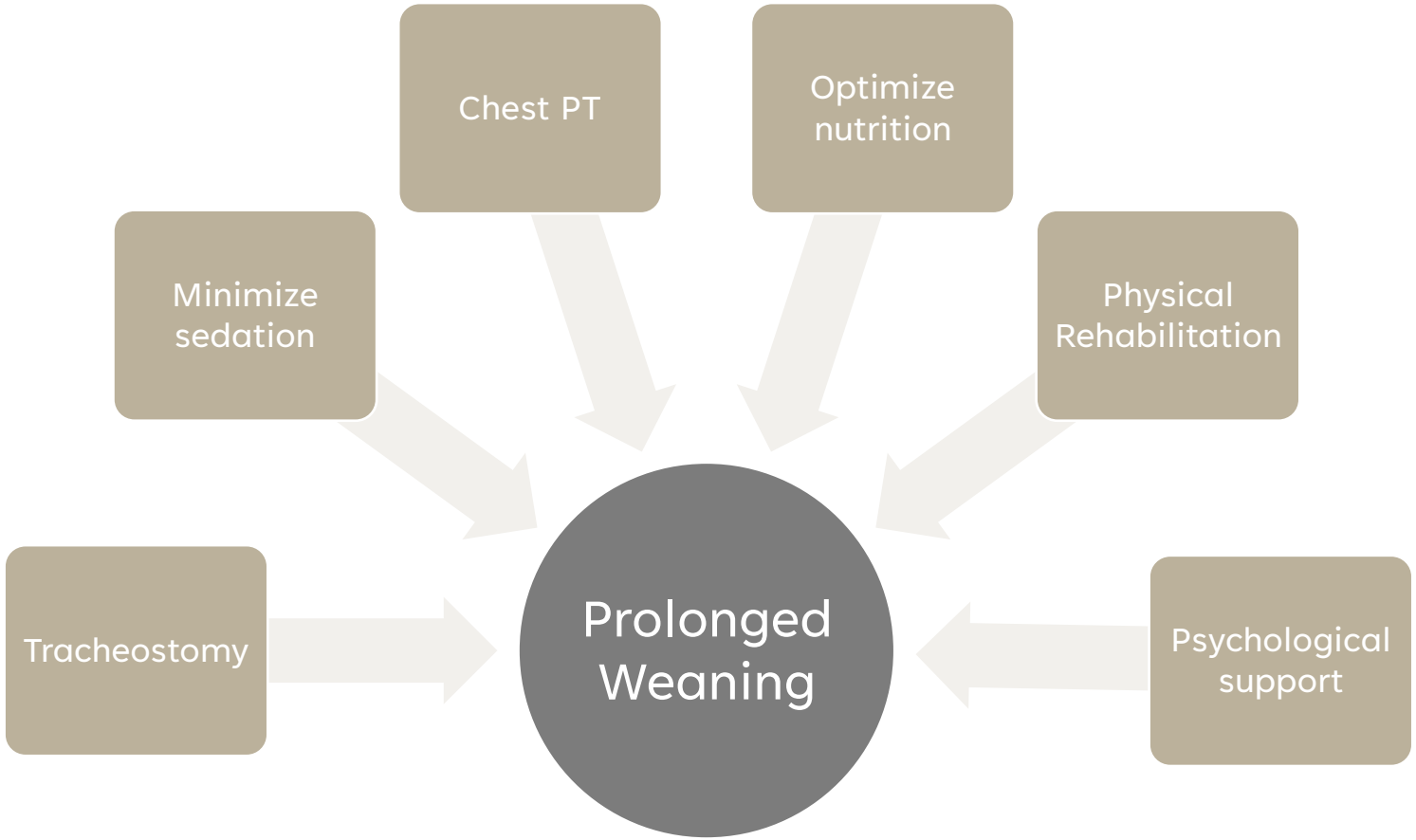
(Neeraj M Shah et al., Prolonged weaning from mechanical ventilation; Who, What, When, and How?, 2024)

Also will require INTENSIVE input from PT/OT Dietician Psychologist, etc.



# MANAGEMENT STRATEGIES TO IMPROVE

(NEERAJ M SHAH ET AL., PROLONGED WEANING FROM MECHANICAL VENTILATION; WHO, WHAT, WHEN, AND HOW?, 2024)



# CHALLENGES FOR PROLONGED MV PATIENTS

Medically complex

Elderly, Socioeconomically disadvantaged

Marginalized individuals

Rely on **ventilator weaning facility & skilled nursing homes**

**Home ventilation**

*(Tamas Dolinay, et al. Ventilator Weaning in Prolonged Mechanical Ventilation – A Narrative Review, 2024)*

# CHALLENGES FOR PROLONGED MV PATIENTS

**Specialized Weaning Unit**

Downgrade from ICU/Respiratory Care Units in Acute Care Hospitals

Regional weaning centers

34-60% in specialized weaning unit can be weaned successfully

Maybe cost-effective alternative to ICU

Recommendation of the use of clearly defined protocols

*(Tarek Sabry, Difficult Weaning from Mechanical Ventilator, 2017)*

# CHALLENGES FOR PROLONGED MV PATIENTS

**Specialized Weaning Unit**

Presence of tracheostomy tube

Clinically stable and potential to benefit from rehabilitation

Acceptable nurse/patient ratio

Required supervised pulmonary physician

Qualification of Respiratory therapists

Presence of certain specialists (PT/OT, ST, nutritionist, psychologists)

*(Tarek Sabry, Difficult Weaning from Mechanical Ventilator, 2017)*

# CHALLENGES FOR PROLONGED MV PATIENTS

*(TAREK SABRY, DIFFICULT WEANING FROM MECHANICAL VENTILATOR, 2017)*

**Home Ventilation**

Discharged home with ventilator support

Using NIV or MV via tracheostomy

Beneficial for patients with progressive neuromuscular diseases

**Terminal Care**

Withdrawal of ventilation??

Routine palliative care or ethics consultation

Quality of Communication skill for terminal care

Family and friends' aspects

# FINAL TIPS & TAKEAWAYS

- Unless there is an evidence for clearly irreversible disease/factors a patient requiring prolonged ventilatory support should not be considered “permanently ventilator dependent” ; keep seeking !!
- On the other hand, needs evaluation for the benefits and **potential harms** of continued ventilator care
- Further research is needed who would benefit from ongoing weaning attempts

# MAHALO

Kimi Yamasaki, RRT

yamasakh@ah.org

Adventist Health Castle

Islands Skill Nursing & Rehabilitation