

Sudden deterioration of a neonate on noninvasive and invasive respiratory support

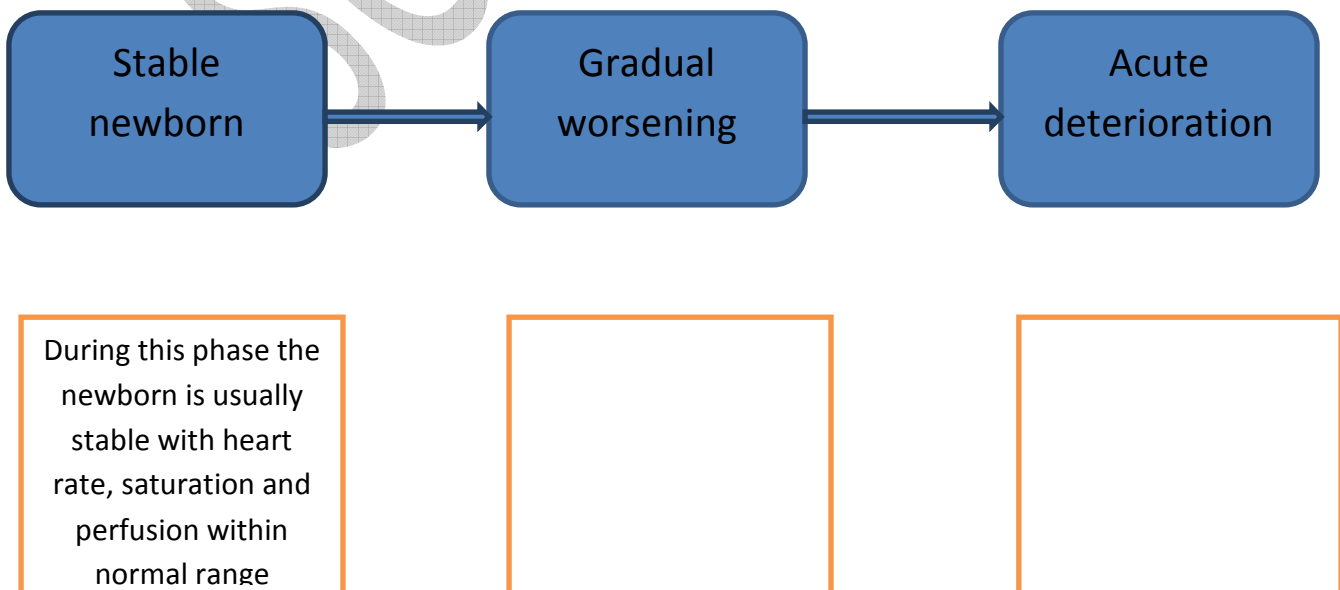
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Introduction

- Intensive care is associated with adverse outcomes, often independent of the underlying disease process (1)
- Deterioration events are fairly common in the neonatal intensive care unit, can be anticipated in few conditions while most are sudden and unanticipated (2) and can have long lasting repercussions.
- Majority of the deterioration episodes are manifested as **sudden collapse** of a neonate on invasive or noninvasive support with all or few of the following
 - a. desaturation
 - b. cyanosis
 - c. bradycardia
 - d. hypotension
 - e. cardiorespiratory arrest

The usual sequence as observed in most cases of deterioration is as depicted below

Fig 1: Sequence of worsening



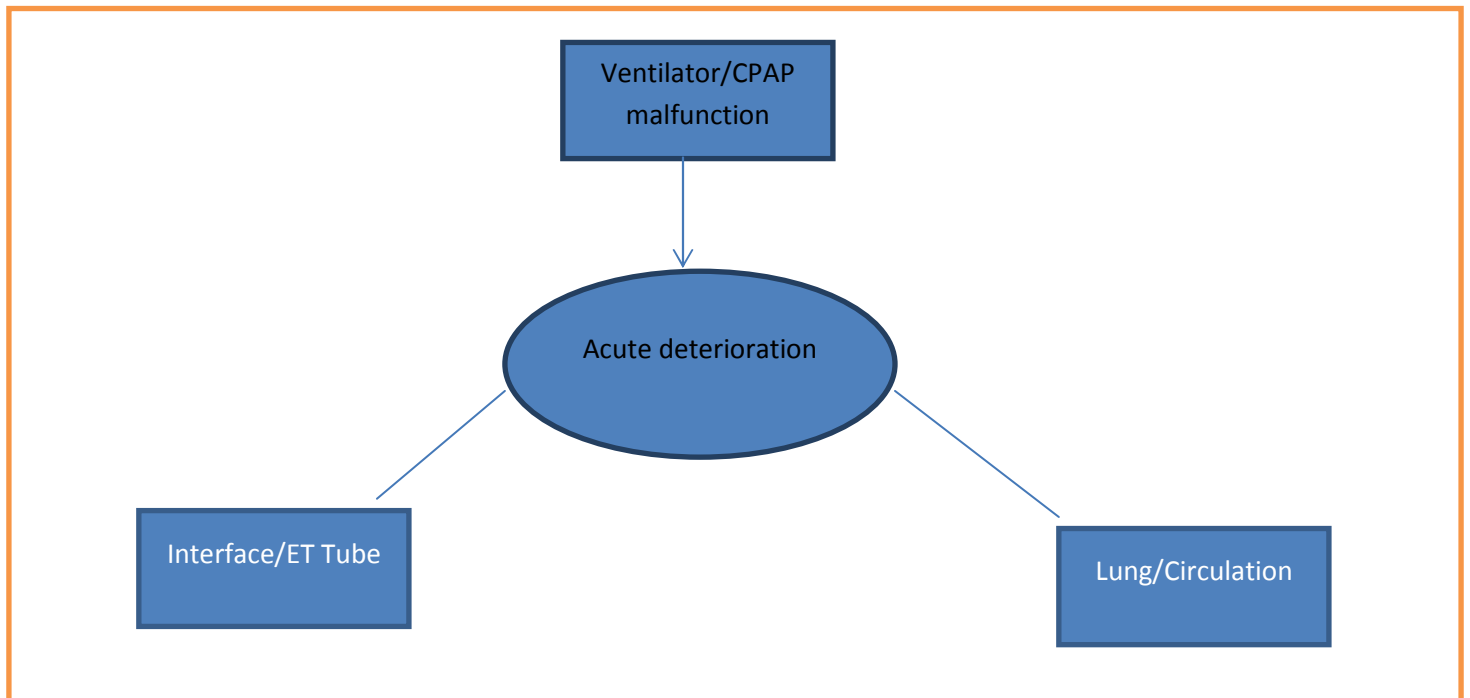
Thus, the time period between the gradual worsening and deterioration phase provides a window of opportunity and action and maximum efforts should be directed towards identifying babies during this period. Few events like cardiac arrhythmias, convulsive apnea may however not follow the above sequence.

2. Causes and differential diagnosis:

- Most causes are common to both babies on non-invasive and invasive support and can be classified on the basis of their origin as-
 - a. Machine related (ventilator, CPAP machine, HFNC)
 - b. Interface, Endotracheal tube(ET) related
 - c. Lung/ Circulation related

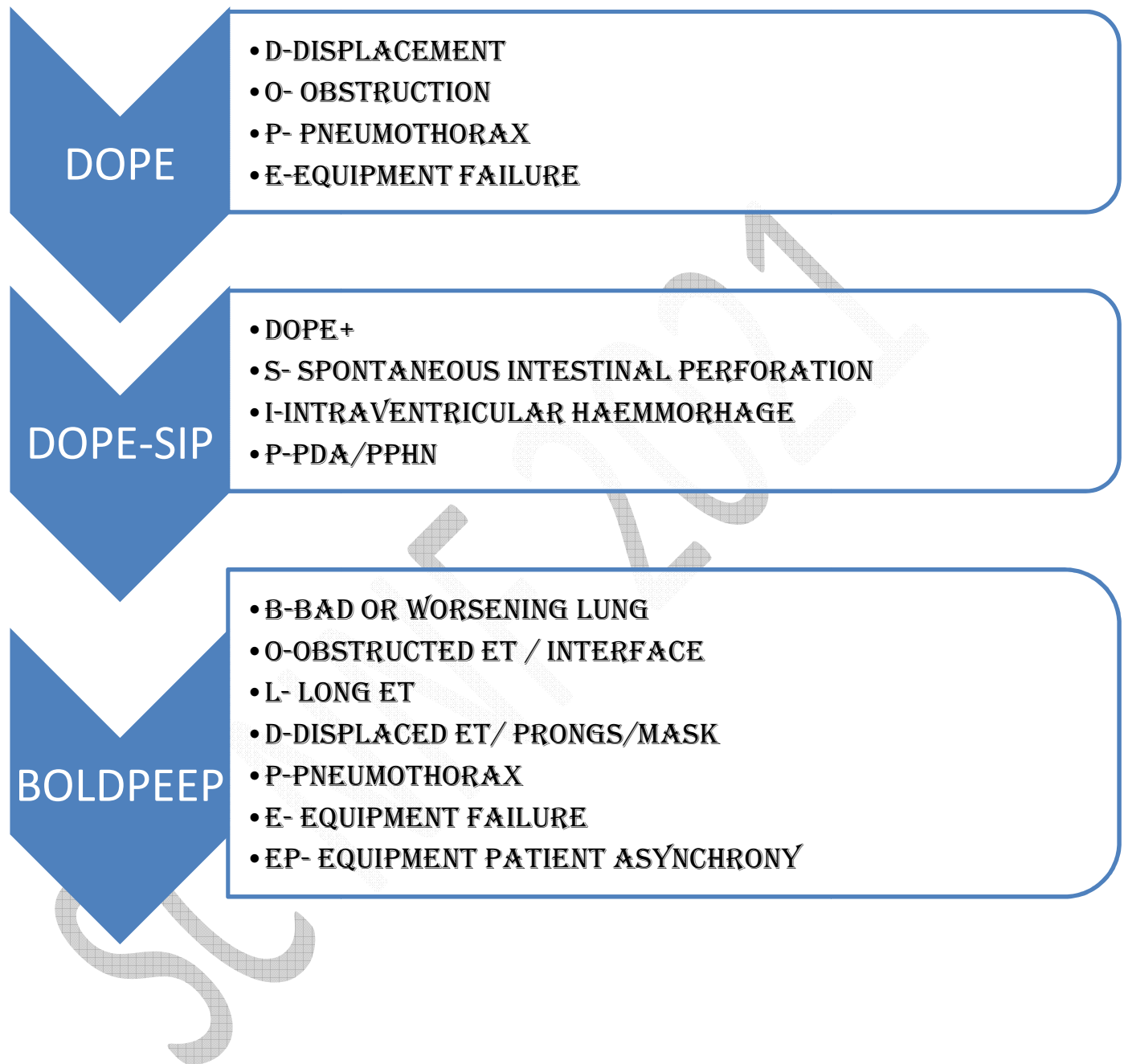
Table 1: Causes of worsening

MACHINE	INTERFACE	LUNG/CIRCULATION
a. Ventilator malfunction b. Circuit leak c. Blender /compressor failure d. Failure to address alarms e. Inappropriate settings	a. Self extubation b. Tube block with secretions, blood c. Kinked, compressed tube d. Interface displacement e. Nasal block	a. Pneumothorax b. Worsening of lung disease c. Persistent pulmonary hypertension/ Patent duct arteriosus (PPHN/PDA) d. Uncompensated shock, acute blood loss e. Arrhythmia

Fig 2: Causes of worsening

With technical advances and routine use and availability of bedside graphic and blood gas, newer additions have been made. (3)

Fig 3: Approach to sudden deterioration:



The **BOLDPEEP** approach shall be discussed in detail below. (4)

Table 2: BOLDPEEP approach

	History and examination	Charts, blood gas, xray	Pulmonary graphics	Action
B	<p>a.HISTORY:No steroids. PPROM, high fio2</p> <p>b.EXAM: poor chest movement, reduced air entry, negative cold light</p>	<p>a.CHARTS: rising Fio2 trend, increasing PIP</p> <p>b.BLOOD GAS: respiratory or mixed acidosis</p> <p>c.X-RAY: RDS, low volume lungs, consolidation</p>	<p>Low compliance, high resistance, flat pv loop</p>	<p>Increase PIP/MAP surfactant increase FIO2 step up antibiotics</p>
O	<p>a.HISTORY: sepsis, secretions, frequent suctioning</p> <p>b. EXAM: Variable chest movement, reduced air entry, crepts, wheeze</p>	<p>a. CHARTS: rising Fio2, frequent suctioning, desaturations periodically</p> <p>b. BLOOD GAS: respiratory acidosis</p> <p>c.X-RAY: Variable collapse, consolidation, aspiration</p>	<p>Variable blunted flows, serrated patterns on flow loop, variable compliance /resistance</p>	<p>Frequent suctioning Change tube if blocked Increase in PIP/Fio2 may be needed briefly</p>
L	<p>a.HISTORY: no improvement on ventilator</p> <p>b.EXAM: poor unilateral left</p>	<p>a.CHARTS: Rising fio2, desaturations</p>	<p>High resistance Blunting of</p>	<p>Pull out ET tube</p>

	sided air entry and chest movement	<p>b.BLOOD GAS: Respiratory acidosis , hypoxemia</p> <p>c.XRAY: Long ETT, asymmetry, hyperinflation and collapse</p>	volume and flow scalars	
D	<p>a.HISTORY: sudden desaturation with no response to ambu, Tpiece</p> <p>b.EXAM: No air entry, chest rise, audible leak</p>	<p>a.CHARTS: previously stable, recent handling</p> <p>b.BLOOD GAS: previously normal</p> <p>c.XRAY: No tube seen</p>	No expiratory flow, incomplete loops, ET disconnected, low MV alarms	<p>Reintubate</p> <p>Fix interface promptly on non-invasive</p>
P	<p>a.HISTORY: No steroids, severe RDS, MAS, drop in blood pressure</p> <p>b.EXAM: asymmetry, transillumination positive, reduced air entry</p>	<p>a.CHARTS: sudden deterioration</p> <p>b.BLOOD GAS: respiratory or metabolic acidosis</p> <p>c.XRAY: pneumothorax, pneumomediastinum</p>	Air trapping in trends before the event, leak, autocycling	<p>Bedside tapping/intercostal drainage</p>
E	<p>a.HISTORY: frequent alarms, water in circuit, central line inserted recently</p> <p>B.EXAM: poor chest</p>	<p>a.CHARTS: frequent alarms</p> <p>b.BLOOD GAS</p> <p>c.XRAY</p> <p>b.BLOOD GAS: previously stable</p>	Obstructive pattern on flow loop if water in circuit	<p>Address alarms</p> <p>Check circuit</p> <p>Change circuit</p> <p>Biomedical engineer</p>

	movement, reduced air entry, improvement on Tpiece	c.XRAY: misplaced central lines(arrhythmia,pleural effusion)		
EP	a.HISTORY:bad lung disease, no sedation, irritable baby b.EXAM:active baby,retractions,irritability	a.CHARTS: rising Fio2, high pain score, desaturations, high BP b.BLOOD GAS: variable, respiratory alkalosis c.XRAY: significant lung disease	High resistance, beaking on PV loop, auto trigger	Sedation Synchronized modes Adjust trigger Extubation if ready

3. APPROACH TO DIAGNOSIS

- The following questions should be asked when faced with a collapsing baby
 - A. How stable was the baby previously?
 - B. How rapidly is the patient deteriorating?
 - C. How much time do we have, do we analyze and investigate or act first?

STEPWISE APPROACH:

- a. Ensure that at least two people are available for management- a leader and an assistant
- b. Necessary working equipment available at bedside
- c. Systematic management and investigative workup simultaneously

a. Preliminary steps :

Disconnect patient from ventilator

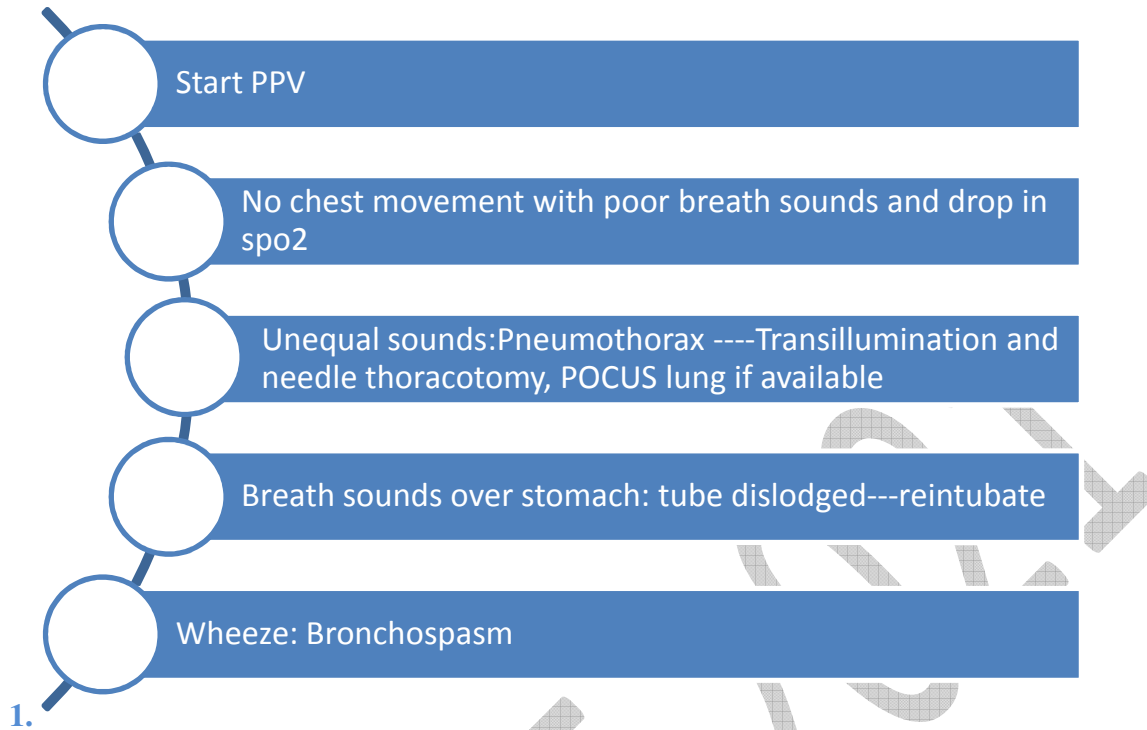
Connect ambu bag/Tpiece to ET

Make sure O2 supply and reservoir bag is available

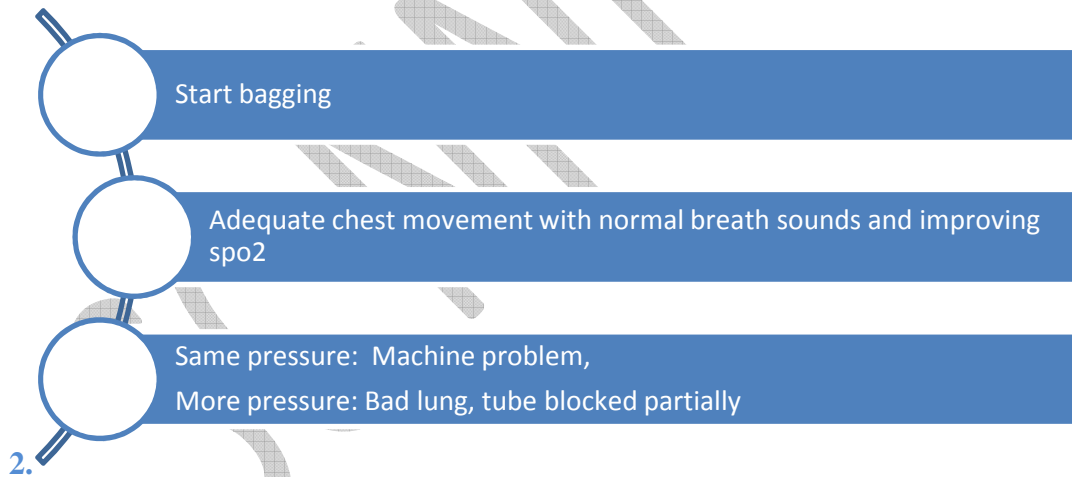
Start bagging at ventilator rate

The following 3 scenarios are possible at this juncture:

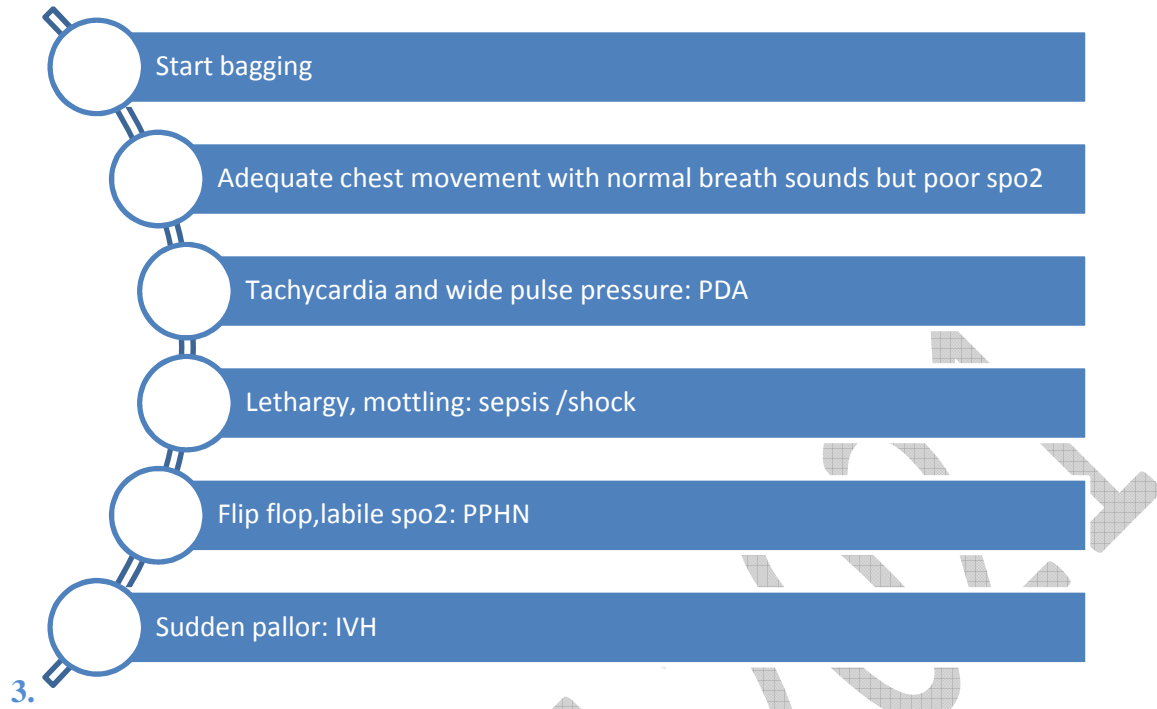
1. Poor chest rise and falling spo2
2. Adequate chest rise and improving spo2
3. Adequate chest rise and falling spo2



Steps in babies with poor chest rise and falling spo2



Steps in babies with adequate chest rise and improving spo2



Steps in babies with adequate chest rise and falling spo2

Fig 4: Algorithmic approach for sudden collapse on mechanical ventilation (Ready-reckoner) (5)

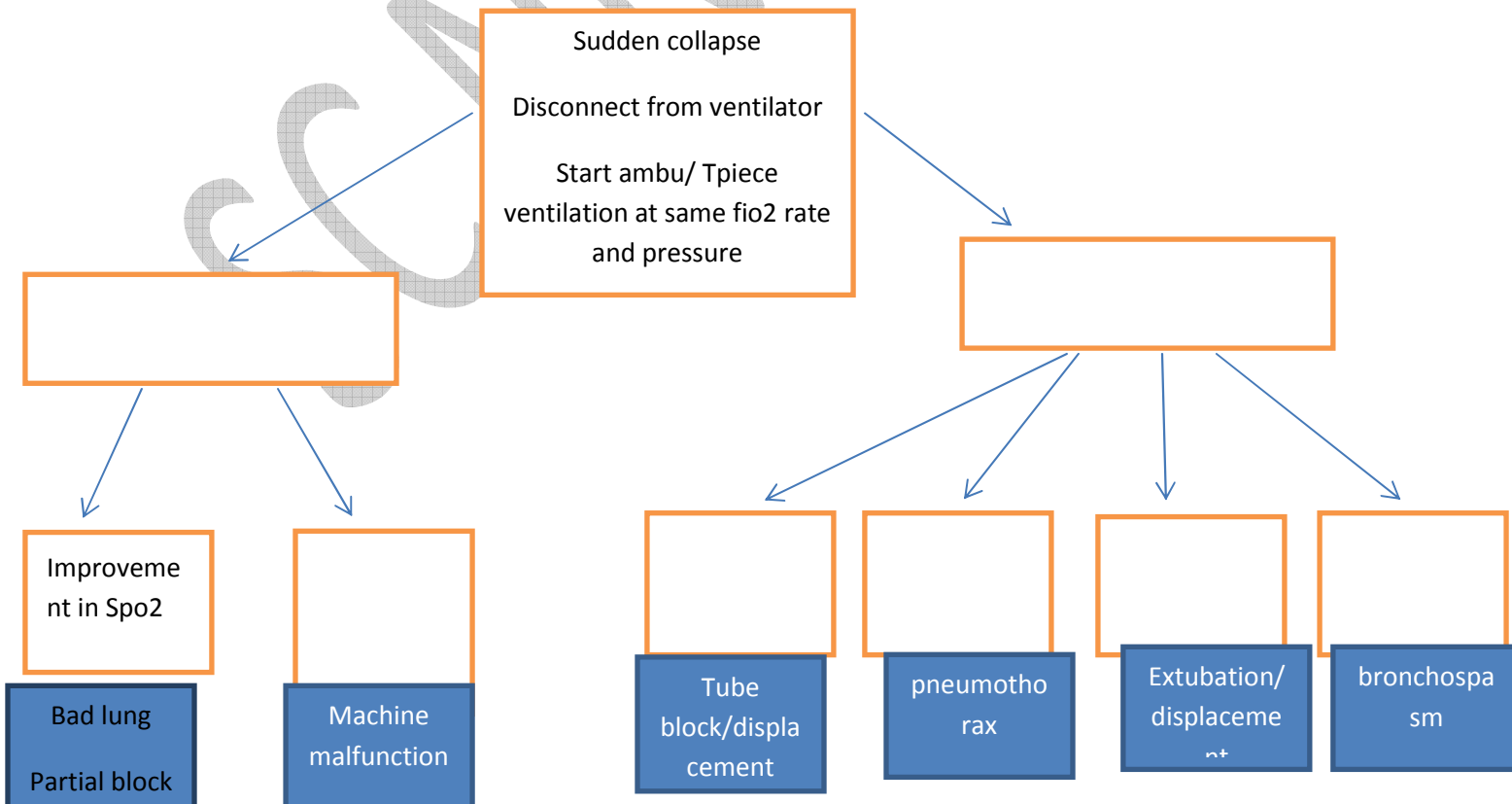
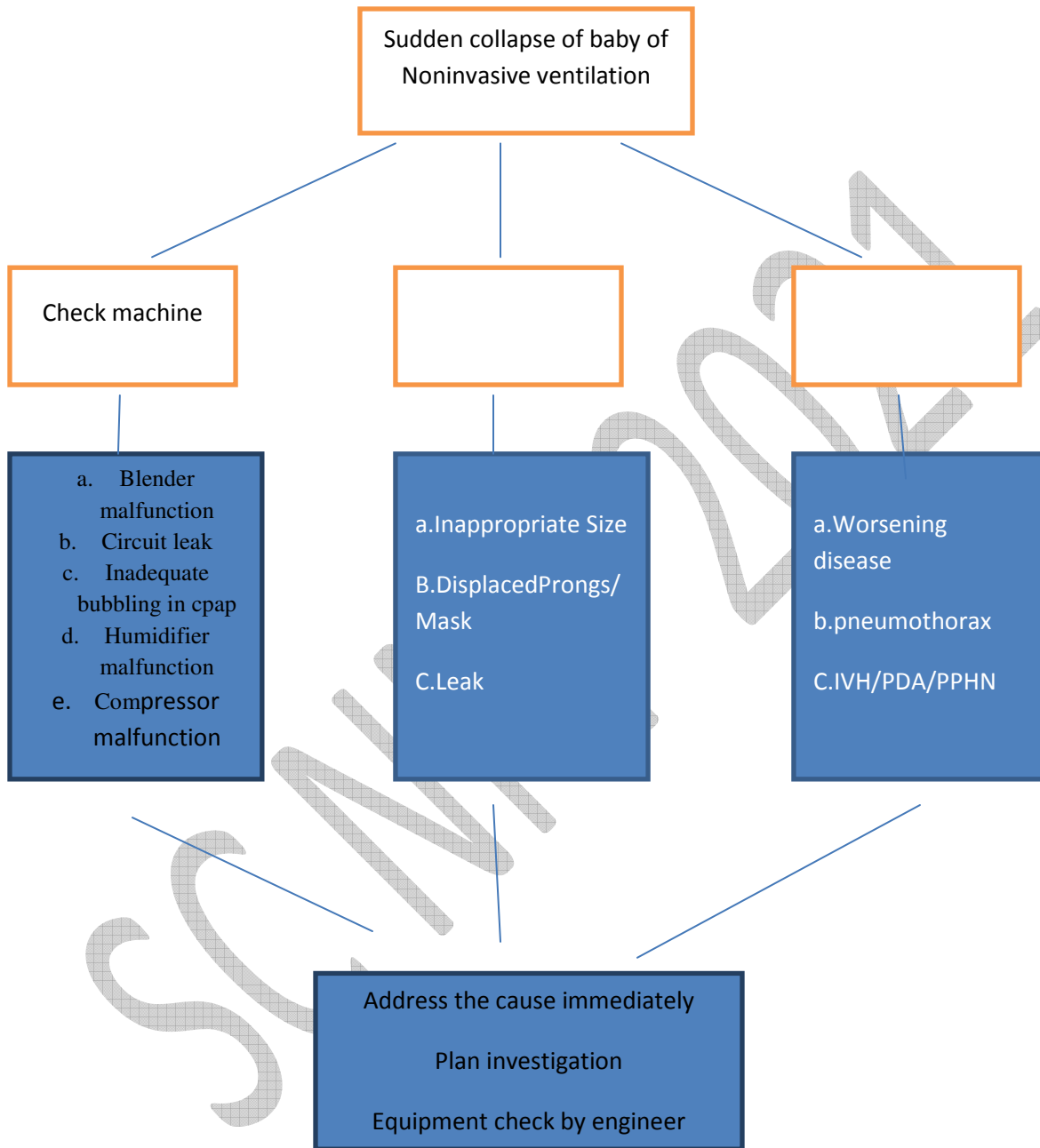


Fig 5: Algorithmic approach for sudden collapse on noninvasive (Ready-reckoner)



4. SUMMARY AND PREVENTION:

- Thus, algorithmic and systematic approach on the background of history and clinical examination can aid in quick diagnosis and crisis aversion.
- Anticipation is the key, rigorous monitoring and action before deterioration.
- Retrospective analysis and audit periodically.
- Integration of quality improvement principles (5).
- Simulation and periodic training and testing of all stake holders.

Table 3: PREVENTIVE STEPS

1. Interface fixation
2. Timely suction
3. Alertness and diligent monitoring
4. Bedside equipment check in each shift
5. Simulation and training
6. Early extubation

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