

# Acute Respiratory Failure In Pregnancy

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Critical Care Obstetrics

# Objectives

- ▶ Respiratory physiology in pregnancy
- ▶ Causes of respiratory failure
- ▶ ICU management during pregnancy



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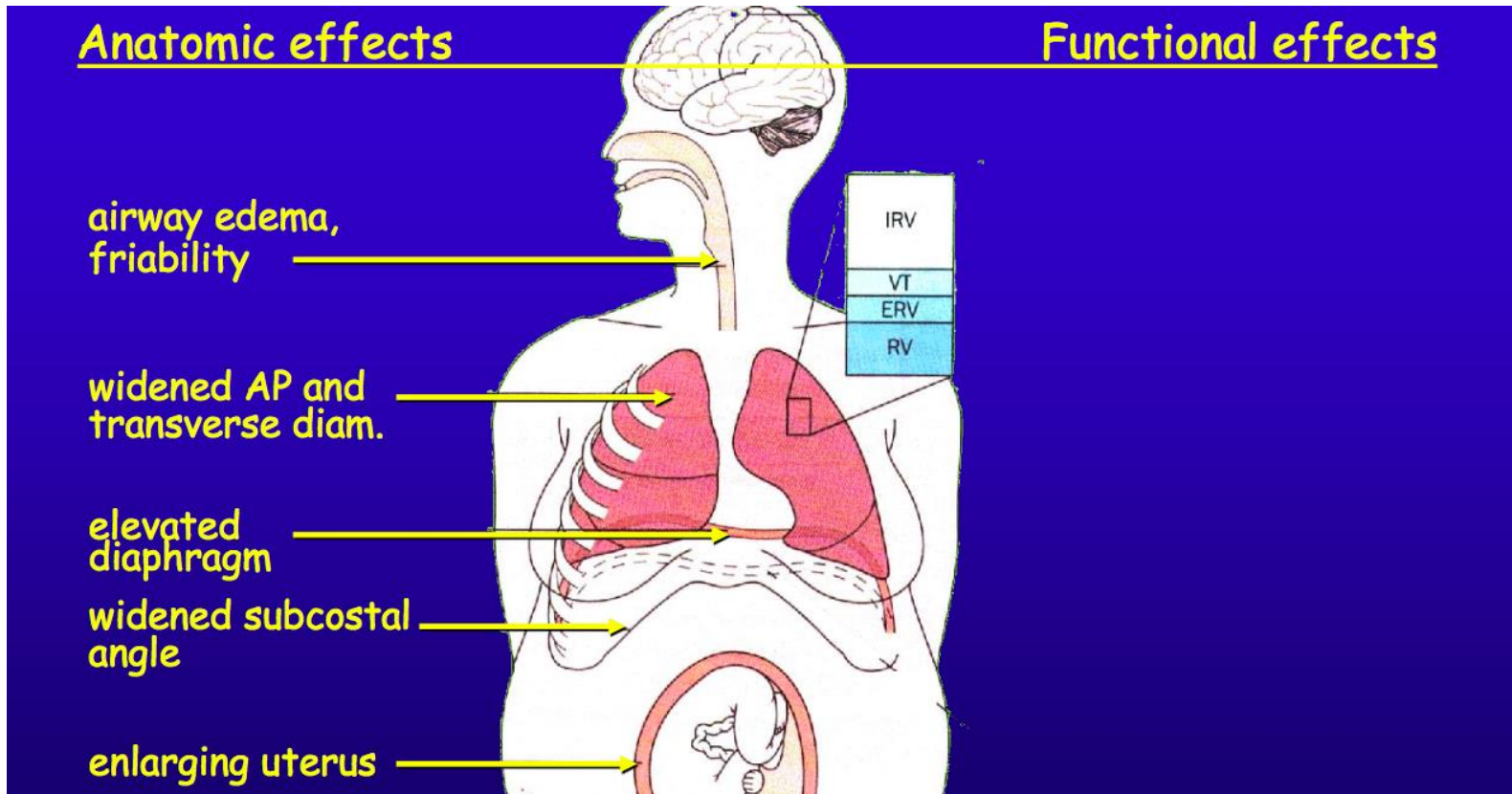
# Introduction

- ▶ Critical conditions warranting admission of pregnant patients to Intensive Care Unit (ICU) are relatively rare and incidence varies between 0.7% and 13.5% of all ICU admissions. Intensive Care Med 2010
- ▶ Acute respiratory failure (ARF) is the most frequent organ dysfunction associated with ICU admission and has dire maternal and fetal consequences if left untreated.
- ▶ Pregnancy may increase the risk or severity of other conditions, including thromboembolism, asthma, viral pneumonitis, and gastric acid aspiration.

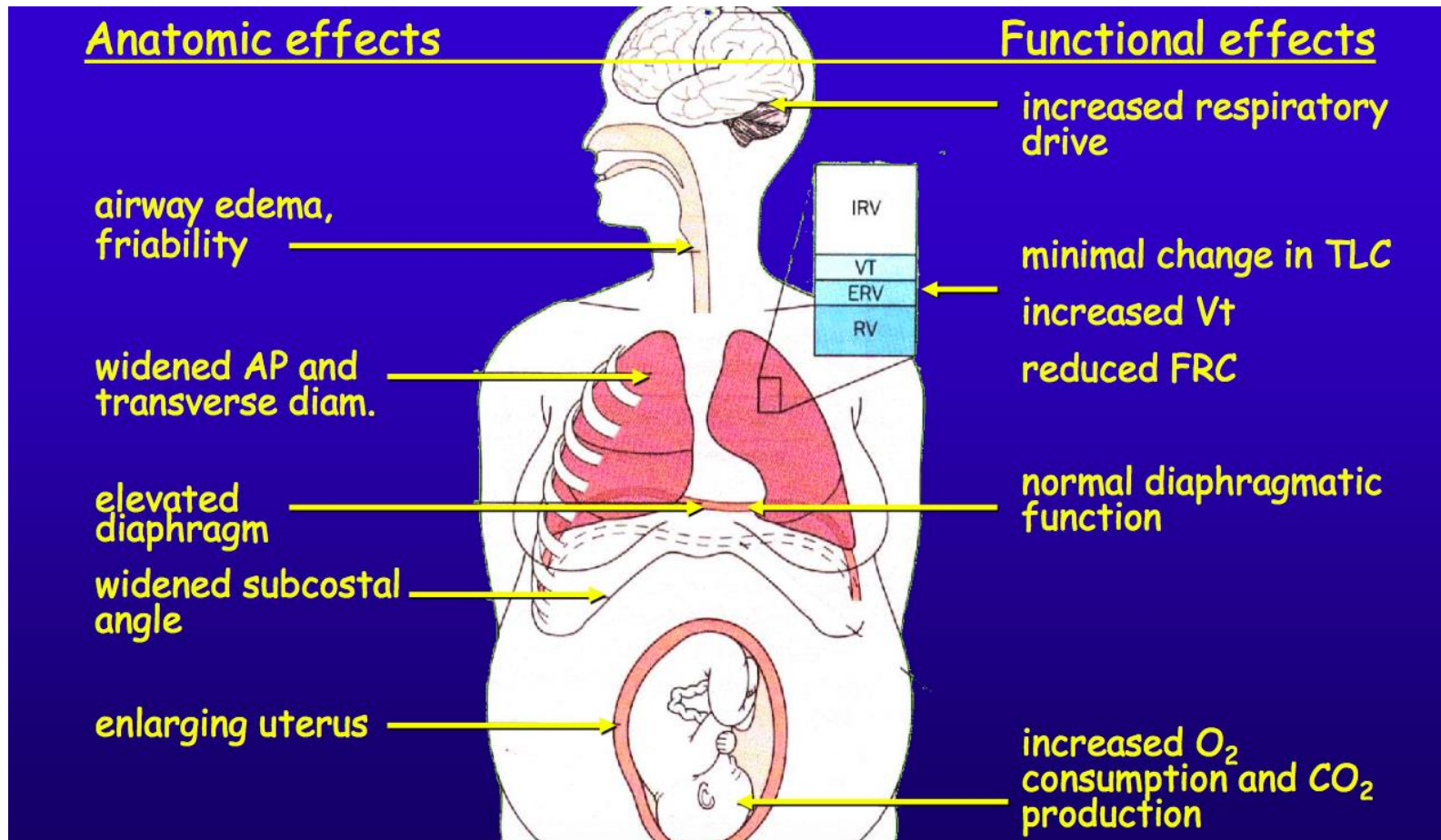


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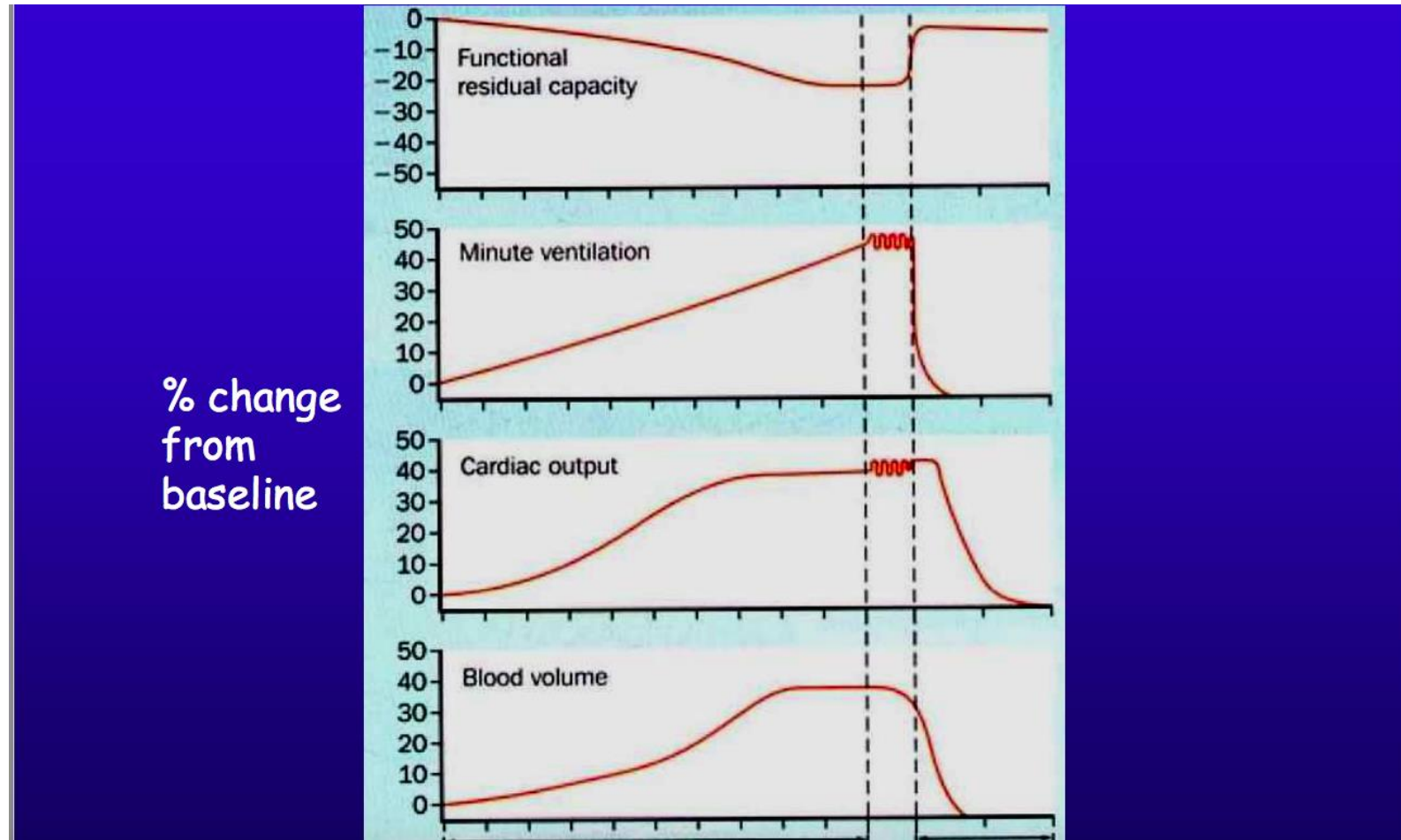
# Respiratory Physiology in Pregnancy



# Respiratory Physiology in Pregnancy



# Respiratory Physiology in Pregnancy



# Acute respiratory failure in pregnancy

- ▶ Inadequate gas exchange due to pulmonary or extra pulmonary conditions may produce hypoxemic or hypercapnic respiratory failure.
- ▶ Maternal mortality is high when critical care is required with estimate ranging from 3.4-14%
- ▶ In United states, leading cause of maternal mortality is death due to rising maternal age and high incidence of obesity, diabetes and HTN.



# Acute respiratory failure

- ▶ Among those who are admitted to an ICU, the most common indications are postpartum hemorrhage and hypertensive disorders.
- ▶ Acute respiratory failure requiring mechanical ventilation is a rare complication of pregnancy affecting 0.1 to 0.2 % of pregnancies.



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# Blood Gases

- ▶ The normal partial pressure of carbon dioxide ( $\text{PaCO}_2$ ) during pregnancy is 27-34 mmHg and partial pressure of oxygen ranges between 90-110mmHg.
- ▶ Increase in oxygen demand coupled with decrease in FRC causes small airways to close earlier when lung volumes are reduced, putting pregnant patients at risk of rapid desaturation.
- ▶ Delivery of  $\text{O}_2$  to the fetus is affected by maternal delivery of  $\text{O}_2$  to the placenta and placental transfer.
- ▶ Frequent and severe episodes of hypoxia lead to low birth weight, intra uterine growth retardation, preterm delivery and increased perinatal morbidity and mortality.

Uterine blood flow normally maximally dilated, is decreased by alkalosis, hypotension, and catecholamine's.



# Obstetric Causes Of Acute Respiratory Failure

- ▶ Pregnancy specific
  1. Preeclampsia and pulmonary edema
  2. Amniotic fluid embolism
  3. Tocolytic induced pulmonary edema
  4. Peripartum cardiomyopathy



# Obstetric Causes Of Acute Respiratory Failure

- ▶ Aggravated by pregnancy
  1. Gastric acid aspiration
  2. Venous thromboembolism
  3. Sepsis and ARDS( e.g. pyelonephritis, pneumonia)
  4. Cardiac failure, stenotic valvular heart disease
- ▶ OTHER
  1. Trauma
  2. Asthma
  3. Neuromuscular disease
  4. Pancreatitis



# Acute Respiratory Distress Syndrome(ARDS)

- ▶ ARDS is not uncommon in pregnancy and is a leading cause of maternal death.
- ▶ The pregnant state may predispose to the development of ARDS by a number of mechanism, including the increased circulating blood volume, the reduced serum albumin level, increased capillary leak.
- ▶ Survival from ARDS appears to be as good or better than in general population because of younger age, lack of comorbidity and reversibility of many of the predisposing conditions.



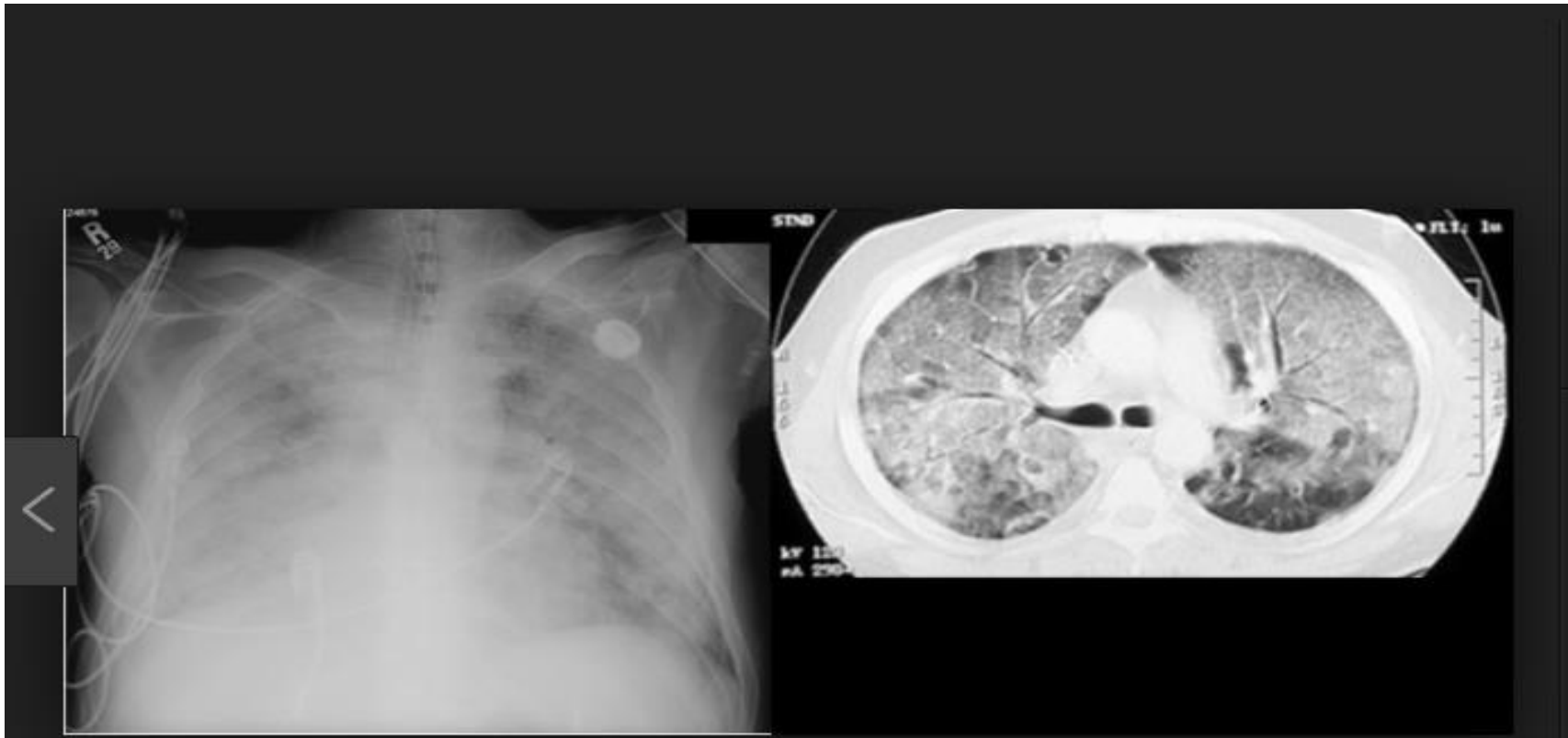
# ARDS

## Berlin Definition of ARDS 2012

| Acute Respiratory Distress Syndrome |  |   |   |
|-------------------------------------|--|---|---|
| Timing                              | Within 1 week of a known clinical insult or new/worsening respiratory symptoms   |   |   |
| Chest Imaging <sup>a</sup>          | Bilateral opacities – not fully explained by effusions, lobar/lung collapse, or nodules  |   |   |
| Origin of Edema                     | Respiratory failure not fully explained by cardiac failure or fluid overload;<br>Need objective assessment (e.g., echocardiography) to exclude hydrostatic edema if no risk factor present |   |   |
|                                     | Mild   | Moderate  | Severe  |
| Oxygenation <sup>b</sup>            | 200 < PaO <sub>2</sub> /FiO <sub>2</sub> ≤ 300<br>with<br>PEEP or CPAP ≥ 5 cmH <sub>2</sub> O <sup>c</sup>   | 100 < PaO <sub>2</sub> /FiO <sub>2</sub> < 200<br>with<br>PEEP ≥ 5 cmH <sub>2</sub> O | PaO <sub>2</sub> /FiO <sub>2</sub> < 100<br>with<br>PEEP ≥ 5 cmH <sub>2</sub> O |



# ARDS



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# ARDS in Pregnancy

## ▶ **Obstetrics causes**

1. amniotic fluid embolism
2. preeclampsia
3. septic abortion
4. retained products of conception

## ▶ **Non obstetrics causes**

1. sepsis
2. aspiration pneumonia, especially gastric acid aspiration
3. blood transfusions
4. trauma
5. influenza pneumonia



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# Transfusion related Acute Lung Injury (TRALI)

- ▶ TRALI is a complication of blood component therapy which may occur in pregnancy.
- ▶ The clinical presentation is of sudden onset of dyspnea during or within 6 hrs of transfusion of plasma containing blood products.
- ▶ The clinical picture is indistinguishable from ARDS.
- ▶ Management is supportive.



# Magnesium Toxicity

- ▶ Magnesium sulfate ( $MgSO_4$ ) is the drug of choice for seizure prophylaxis in pre-eclampsia patients.
- ▶ Mechanism of action is mediated via NMDA receptors in the hippocampus and by antagonizing calcium mediated cerebral vasoconstriction.
- ▶ After administration, about 40% of plasma magnesium is protein bound. The unbound magnesium ion diffuses into the extravascular and extracellular space.
- ▶ The first warning of impending toxicity in the mother is loss of the patellar reflex at plasma concentration between 3.5 and 5mm/L.



# Magnesium Toxicity

- ▶ The therapeutic plasma level is 4.8-8.4 mg/dL
- ▶ Magnesium Sulfate has an extremely good safety record in pregnancy.
- ▶ It is vital, however that the patient is monitored for signs of toxicity. If there is any suspicion, a plasma level should be checked(2 hours after loading dose and every 6 h during maintenance therapy).
- ▶ Magnesium can be used, but only after ensuring that
  - a) The patellar reflex is present
  - b) Respirations are not depressed
  - c) Urine output the previous 4hr exceeded 100 ml



# Magnesium Toxicity

- ▶ Signs of toxicity are as follow
  - a) 9-12 mg/dL Loss of patellar reflexes, feeling of warmth
  - b) 10-12 mg/dL Slurred speech, somnolence
  - c) 15-17 mg/dL Paralysis of skeletal muscle and apnea
  - d) 30-35 mg/dL Cardiac arrest



# Management Plan

- ▶ Management plan
- ▶ Stop administration of magnesium
  - a) Airway :Assess, maintain patency, check pulse oximeter and apply oxygen
  - b) Breathing: Assess, assist, protect airway
  - c) Circulation : Assess pulse and BP, Tilt to left, ECG monitor, IV access and treat hypotension
  - d) Give 10 ml of 10% Calcium gluconate IV over 2-5 min if magnesium toxicity is likely.
  - e) Continuously monitor fetal heart .



# Peripartum Cardiomyopathy

- ▶ It is rare form of serious potentially life threatening heart disease of uncertain etiology occurring in 3<sup>rd</sup> trimester or upto 6 months after delivery
- ▶ Maternal mortality rate(MMR) is 20-50%.
- ▶ Restricted sodium diet, loop diuretics, vasodilators, inotropes, beta blockers, ACE inhibitors, ventricular assist device and heart transplantation have been used for the management.



# Pulmonary edema

- ▶ Patients with cyanotic heart disease, left heart valvular stenotic lesions, or systolic dysfunction are at most risk with pulmonary edema occurring during pregnancy or postpartum, related to large shifts in intravascular volume associated with delivery.
- ▶ Preeclampsia can result in pulmonary edema which occurs in 2.9% of patients.
- ▶ Pulmonary edema may sometimes occur during the systemic administration of beta<sub>2</sub> sympathomimetic agents used to inhibit premature labor.



# Restrictive lung Disease

- ▶ Women with chest wall restrictive disease e.g. kyphoscoliosis or neuromuscular weakness may not be able to meet the increased ventilation requirements of pregnancy, putting them at risk of respiratory failure.
- ▶ Successful pregnancy outcome in women with vital capacities less than 40% predicted.
- ▶ Assessment may need PFT, ABG and echo.
- ▶ Non invasive ventilation has been used to support respiratory function through the latter part of pregnancy and during labor.
- ▶ Marked obesity may also reduce lung volumes.



# Amniotic fluid embolism

- ▶ It occurs in about 7.7 /100,000 pregnancies.
- ▶ Occurs related to labor and delivery or after uterine manipulation.
- ▶ Characterized by development of severe dyspnea and hypoxemia, followed by seizures and cardiovascular collapse or arrest.
- ▶ Management consists of supportive care for the associated DIC and left ventricular and respiratory failure.



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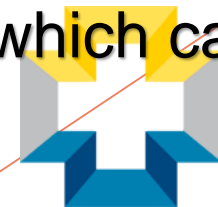
# Asthma

- ▶ Asthma affects 4% to 8% of the general population and is a common pulmonary disorder in pregnancy.
- ▶ Approximately a third of asthmatics remain unchanged during pregnancy, while a similar proportion deteriorate or improve.
- ▶ Asthma during pregnancy is associated with adverse effects, including an increased incidence of preterm labor, low neonatal birth weight, increased perinatal mortality, and an association with preeclampsia, chronic HTN, and complicated labor.
- ▶ Management of the acute asthmatic attack during pregnancy is not different as non pregnant patients.
- ▶ In general ,the risks of poorly controlled asthma far outweigh the possible adverse effects of drug therapy.



# Management of Asthma

- ▶ Selective short acting beta<sub>2</sub> agonists have demonstrated an acceptable safety profile for the fetus.
- ▶ Non selective beta agonists as epinephrine carry a risk of uterine vasoconstriction and are probably best avoided for treatment of asthma.
- ▶ Systemic corticosteroids are indicated.
- ▶ Halogenated corticosteroids such as prednisolone, prednisone do not cross the placenta to a significant degree, so fetal and neonatal adrenal suppression is not a major concern.
- ▶ Labor and delivery carry some risk due to drugs commonly given.
- ▶ Narcotics other than fentanyl may release histamine ,which can worsen bronchospasm.



# Pulmonary Infections

- ▶ Down regulation of cell mediated immunity occurs, balanced by an intact or up regulated humoral immune response.
- ▶ Pneumonia is a significant cause of maternal and fetal morbidity and mortality.
- ▶ Pregnancy is associated with an increased risk of complications of pneumonia, including respiratory failure.
- ▶ Pneumonia may produce preterm labor, small for gestational age, and intrauterine and neonatal death.
- ▶ Bacterial pneumonia has a similar microbiologic spectrum to the usual CAP in non pregnant patients.



# Pulmonary infections

- ▶ Antibacterial therapy is similar to treatment in the non pregnant patients, although drugs like tetracycline and quinolones should be avoided if possible.
- ▶ Viral pneumonia carries a risk of significant morbidity in pregnancy, with increased mortality rates compared with general population.
- ▶ Vaccination of pregnant women is strongly recommended.
- ▶ Varicella pneumonia is also associated with significant morbidity and mortality during pregnancy. Treatment with acyclovir is necessary and reduces mortality.
- ▶ Fungal pneumonia are uncommon .Coccidioidomycosis is more likely to disseminate because of impaired cell mediated immunity and effect of progesterone on fungal proliferation. Amphotericin is the accepted therapy.



# Initial Management

- ▶ Initial management is the same regardless of the cause of the acute respiratory failure.
- ▶ Supplemental oxygen should be administered.
- ▶ Oxygen can be delivered by nasal cannula, face mask, high flow nasal cannula or a non rebreather mask.



# Management of Acute Respiratory Failure

- ▶ Although a  $P_{aO_2}$  of 55 mmHg and an  $S_{aO_2}$  of 88% would be tolerated in the general population, adequate fetal oxygenation requires a  $P_{aO_2}$  of  $> 70$  mmHg, which corresponds to maternal  $S_{aO_2}$  of about 95%.



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# Management of Acute Respiratory Failure

- ▶ During much of pregnancy and the initial stage of any maternal decompensation, the best support for the fetus is to maintain a non hostile intrauterine environment by supporting the mother.
- ▶ The treatment of ARDS in pregnancy closely follows that for the general population and includes supportive care while identifying and treating the underlying cause.



# Management of Acute Respiratory Failure

- ▶ Management during pregnancy is similar to the non pregnant patients.
- ▶ Endotracheal intubation in pregnancy carries an increased risk, due to airway edema and rapid oxygen desaturation following apnea.
- ▶ Chest wall compliance is reduced, perhaps permitting slightly higher airway pressures.
- ▶ Delivery of the fetus does not always improve maternal respiratory function, but should be considered if benefit to the fetus is anticipated.



# Ventilatory management in the pregnant patient

## *Noninvasive ventilation*

- ▶ Non invasive ventilation is well suited to short term ventilatory support , and avoids the potential complications of endotracheal intubation and the associated sedation.
- ▶ It has a role in obstetric respiratory complications which reverse rapidly .
- ▶ Major concern is risk of aspiration. It should therefore only be used in the pregnant patient who is alert, protecting her airway.



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# Non invasive ventilation role

- ▶ Acute respiratory failure
  - Pulmonary edema(cardiogenic, preeclampsia)
- ▶ Chronic respiratory failure
  - Neuromuscular disease
  - Kyphoscoliosis
  - Bronchiectasis



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# Ventilatory management in the pregnant patients

## *Intubation*

- ▶ Endotracheal intubation in pregnant patients carries considerable risk.
- ▶ Failed intubation is 8 times more common in the obstetrics population.
- ▶ Upper airway mucosal edema and friability can adversely affect visualization and increase the risk of bleeding.
- ▶ Nasal intubation should be avoided and a smaller endotracheal tube may be required.
- ▶ Pre oxygenation is important, but over ventilation and respiratory alkalosis must be avoided.
- ▶ The risk of aspiration should always be considered.



# Ventilatory management in the pregnant patient

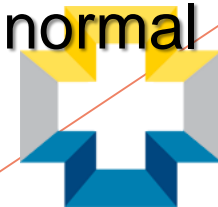
## *Invasive mechanical ventilation*

- ▶ Prolong mechanical ventilation of pregnant patients in the ICU is relatively uncommon.
- ▶ Hyperventilation and alkalosis should be avoided to prevent uterine vasoconstriction.
- ▶ Lung protective ventilation causing permissive hypercapnia has not been assessed in pregnancy.
- ▶ Chest wall compliance is reduced by enlarging uterus, and the usual pressure limits may not be appropriate.
- ▶ Slightly higher airway pressures may be needed to achieve appropriate tidal volumes in pregnant women near term.



# Ventilatory management in the pregnant patient

- ▶ Oxygenation should be optimized to ensure adequate fetal oxygenation.
- ▶ A maternal oxygenation goal of  $P_{o_2} > 70$  mmHg has been suggested. Maternal oxygen saturation is only one factor contributing to fetal oxygenation, placental perfusion usually playing more significant role.
- ▶ Maternal  $Co_2$  levels are normally reduced to about 27 to 34 mmHg, producing a gradient to facilitate placental excretion of fetal  $CO_2$ .
- ▶ The target  $PaCO_2$  is 30-32 mmHg, since this is the normal level during pregnancy.



# Non conventional support

- ▶ Few data available to support the use of interventions such as inhaled nitric oxide, prone positioning.
- ▶ The 2009 H1N1 INFLUENZA epidemic resulted in a marked increased utilization of extracorporeal life support for ARDS, including pregnant patients with reasonably good outcomes.
- ▶ Supportive care also includes managing sedation, pain control, hemodynamic support, volume management, veno thromboembolism prophylaxis, nutritional support.



# Delivery of the fetus

- ▶ It has been suggested that delivery of the pregnant patients with respiratory failure will result in improvement in the mothers condition. However a significant benefit to the mother has not been consistently demonstrated.
- ▶ If the fetus is at a viable gestation and is at risk due to intractable maternal hypoxia, there may be a benefit to the fetus in delivery.
- ▶ Mode of delivery should be determined by standard obstetrical principles.
- ▶ Although Cesarean section may allow rapid delivery, there is significantly increased physiological stress.



# Delivery of the fetus

- ▶ Essential to have prearranged plans for urgent delivery and neonatal resuscitation in the event of spontaneous labor or sudden maternal or fetal deterioration.
- ▶ This should include immediate availability of all necessary equipment, drugs and staff contact details.



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# Nonconventional support

- ▶ Few data are available to support the use of interventions such as inhaled nitric oxide, prone positioning and high frequency oscillation in pregnancy, although these modalities have been used successfully and described in case reports.
- ▶ The 2009H1N1 influenza epidemic resulted in a marked increased utilization of extracorporeal life support for ARDS, including pregnant patients with reasonably good outcome.





Thank You



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# QUESTIONS

1) Acute respiratory distress syndrome(ARDS) is a hypoxemic respiratory failure.

T/F

2) Adequate fetal oxygen requires a  $Pao_2 >70$  mmHg which corresponds to maternal  $Sao_2$  of about 95%. T/F

3) Nasal intubation is a preferred way to intubate pregnant patients. T/F

4) The first warning of impending toxicity in the mother is loss of the KNEE reflex at plasma concentration between 3.5 and 5mm/L. T/F

5) Steroid is ok to be given in asthma exacerbation complicating pregnancy T/F



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# Answers

- ▶ 1) T
- ▶ 2) T
- ▶ 3) F
- ▶ 4) F
- ▶ 5) T



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