Take-Home Points

Meconium consists of the thick, greenish intestinal secretions of the fetus. Meconium normally is not passed out of the GI tract until after birth. Common factors associated with meconium release into the amniotic fluid before birth include: placental insufficiency, maternal hypertension, preeclampsia, maternal drug abuse, maternal infection, chorioamnionitis, and fetal hypoxic stress. Although sterile, when aspirated, meconium causes a severe chemical pneumonitis, varying degrees of airway obstruction/air trapping and inactivation of surfactant. The resulting hypoxia and release of chemical mediators causes pulmonary vasoconstriction. In combination these pathophysiologic events constitute the meconium aspiration syndrome (MAS).

MAS is defined as respiratory distress in an infant born through meconium-stained amniotic fluid (MSAF) whose symptoms cannot be otherwise explained. Typically the infant is born at or beyond full term (≥ 37-39 weeks). The syndrome is considered mild if the infant requires less than 40% O2 to maintain adequate oxygenation, moderate if more than 40% O2 is needed, and severe if positive pressure ventilation is necessary to support life. MAS is often associated with persistent pulmonary hypertension (PPHN).

Assessment/Information Gathering

- Diagnosis based on a perinatal history of MSAF combined with signs of respiratory distress in association with certain characteristic X-ray abnormalities
- Evaluate for other perinatal factors associated with MAS: abnormal fetal heart rate patterns, fetal acidosis, Cesarean delivery, and Apgar scores < 7
- Be sure to closely monitor or to recommend monitoring any infant born through MSAF for any signs of respiratory distress for at least 24 hours
- Assess for signs of respiratory distress consistent with MAS: tachypnea, cyanosis, intercostal retractions, grunting, alar/nasal flaring; in severe cases, a 'barrel chest' (increased A-P diameter) may also be observed, due to the presence of air trapping
- Auscultate: breath sounds may reveal coarse bilateral rhonchi and crackles; in those with PPHN, a systolic murmur (indicating tricuspid regurgitation) may be heard over the heart
- Recommend/examine X-ray, looking for diffuse or localized areas of overexpansion/hyperinflation and infiltration/atelectasis; air leaks (pneumothorax, pulmonary interstitial emphysema) may also be evident; if present, cardiomegaly suggests co-existing PPHN
- Recommend echocardiography to: 1) rule out congenital heart disease, 2) assess cardiac function, and 3) determine location/severity of R->L shunting/pulmonary hypertension
- Laboratory Evaluation - Recommend:
  - ABG - may reflect primarily hypoxemia (mild to moderate MAS) or hypoxemia + respiratory and possibly metabolic acidosis (severe MAS)
  - CBC/Differential
    - polycythemia may impair pulmonary blood flow/worsen MAS and PPHN
    - thrombocytopenia increases risk for neonatal hemorrhage
    - neutropenia or neutrophilia may indicate infection
  - Hb + Hct levels - to assess for blood loss and adequacy of blood O2 content
Treatment/Decision-Making

At/After Birth

- If baby is meconium-stained with normal resp effort, muscle tone and heart rate do not intubate; instead clear mouth and nose with a bulb syringe or suction catheter.
- If baby meconium-stained with poor respiratory effort/muscle tone, HR < 100/min:
  - intubate and suction the trachea immediately after delivery
  - if meconium is retrieved and heart rate > 100/min, re-suction
  - if the heart rate < 100/min, administer PPV and consider suctioning again later
- Recommend prophylactic surfactant replacement therapy using the INSURE method (INTubation, SURfactant, Extubation) with prompt extubation to nasal CPAP (can improve oxygenation, reduce pulmonary complications, and decreases need for extracorporeal membrane oxygenation/ECMO).

General Management (typically in a NICU) - Recommend:

- Continuous monitoring of SpO2, BP and perfusion (umbilical artery catheter!)
- Maintaining a neutral thermal environment (to prevent cold stress/ minimize VO2)
- Correcting any electrolyte and acid-base imbalances (can worsen PPHN)
- Maintaining normal blood glucose levels (hypoglycemia can worsen PPHN)
- Maintaining a normal Hb concentration (13-15 g/dL; avoid polycythemia)
- Maintaining mean systemic blood pressure > 45-50 mm Hg via fluid therapy and if needed inotropes, e.g. dopamine (reduces R->L shunting)
- Minimizing stimulation/handling and use of invasive procedures such as suctioning or CPT (stress causes catecholamine release which increases PVR)
- Providing adequate sedation (to avoid stress response), typically via an opioid like fentanyl, often in combination with a benzodiazepine.

Respiratory Care

- Oxygen therapy - provide O2 as needed (via hood or ventilator) to maintain PaO2 55-80 torr/SpO2 88-95% (O2 is a pulmonary vasodilator)
- Intubation and Mechanical Ventilation
  - Recommend for infants with MAS, severe hypoxemia (PaO2 < 50 torr on FIO2 ≥ 0.60; P/F < 100) and respiratory acidosis (pH < 7.25)
  - Goal is to improve oxygenation while minimizing air-trapping/overdistension, barotrauma/air leak syndrome
  - Depending on availability, one can start with conventional or high frequency ventilation (primarily HFOV)
  - If inhaled nitric oxide (iNO) likely to be used for PPHN, recommend starting with HFOV (combined HFOV + iNO is more effective than either alone)
  - Conventional Ventilation
    - Apply lung protective ventilation: VC 4-6mL/kg (VC) or PIP 25-28 cm H2O (PC), rate 40-60/min, expiratory time (0.5-0.7 sec; I:E ≤ 1:1) sufficient to prevent air trapping, 4-7 cm H2O PEEP
    - Aim for PaO2 55-80 torr/SpO2 88-95%, pCO2 40-60 torr, pH 7.3-7.4
    - If co-existing PPHN normalize PaCO2/pH (acidosis worsens PPHN)
    - If air trapping/hyperinflation occurs, lower rate/increase expiratory time and decrease PEEP to 3-4 cm H2O
    - If atelectasis is the primary problem or worsens, increase PEEP up to a maximum of 10 cm H2O
    - Recommend switching to HFOV if two assessments over 3-6 hours reveal:
      - FIO2 needs > 0.60
      - PIP > 30 cm H2O
• mean airway pressure (MAP) > 15 cm H2O
• oxygenation index (OI) > 15-20 (OI=[%O2 x MAP]/PaO2)
  o High Frequency Oscillation Ventilation (HFOV)
    ▪ To minimize air-trapping, set frequency to 6-8 Hz (no higher than 10Hz)
    ▪ Initial MAP may need to be > than on conventional ventilation; use stepwise incremental recruitment to optimize
    ▪ Infants with prominent air trapping and or PPHN may respond poorly to incremental recruitment (fall in PaO2/SaO2 and BP/rise in PVR)
    ▪ Once oxygenation has improved, reduce the MAP in a stepwise fashion (most infants with MAS can be stabilized at 15-20 cm H2O)
• Surfactant Therapy - If on conventional ventilation infant requires FIO2 > 0.50 and MAP > 7 cm H2O, recommend 'rescue' surfactant Tx (in addition to postpartum prophylaxis)
• If MAS complicated with PPHN, recommend a pulmonary vasodilator
  o if available, inhaled nitric oxide (iNO)
    ▪ indication: persistent R->L shunting, high PVR, OI > 20-25
    ▪ starting dose: 20 ppm (therapeutic range is 5-20 ppm)
  o if iNO not available, a phosphodiesterase inhibitors such as sildenafil or milrinone
• Extracorporeal membrane oxygenation (ECMO)
  o Recommend ECMO/transfer to ECMO center if OI > 40 despite optimized medical management, mechanical ventilation and vasodilator therapy
  o Other criteria for ECMO include: 1) > 34 weeks' gestation, 2) birthweight 2,000 g, 3) lack of major bleeding disorder, 4) no major intracranial bleeding, 5) reversible lung disease, 5) duration of mechanical ventilation < 10 to 14 days

**Do Not Recommend**
• CPT/postural drainage, percussion, vibration (causes stress response/increased PVR)
• Hyperventilation (has adverse effect on cerebral circulation and can cause barotrauma)
• Corticosteroids (short-term benefits questionable; may have negative long-term effects)
• Prophylactic antibiotics (do not affect outcomes; only indicated if +cultures)

**Follow-up Resources:**

**Standard Text Resources:**

**Useful Web Links:**


