

**Etiology**

- Genetic instability: Translocation at 14q32 and/or deletion of chromosome 13, leading to either neoplastic plasmacytes producing either a monoclonal immunoglobulin (IgG, IgA, IgD) or isolated light chains (Bence Jones plasmacytoma)
- Environmental and occupational causes
- Radiation (increased incidence in survivors of the atomic bombing of Nagasaki)

**Usual Treatment**

- Alkylating chemotherapeutic agent
- Immunomodulatory drugs: thalidomide, lenalidomide, or pomalidomide

- Stem cell transplantation
  - Autologous
  - Allogenic
- Glucocorticoids
- Interferon alpha-2b
- Protease inhibitors
  - Bortezomib: inhibitor of 26S proteasome > inhibition of proteasome in myeloma
  - Carfilzomib: inhibitor of 20S proteasome > increase in polyubiquitinated proteins

**Treatment of Complications**

- Bone disease-related pain: Opioid preparations, immediate- and extended-release formulations, lidoderm patches, diclofenac topical products; radiation

(refractory pain and cord compression), surgical intervention

- Anemia: Iron, B<sub>12</sub>, folate, erythropoietin, transfusion
- Infection: Vaccination against *Streptococcus pneumoniae*, *Haemophilus influenzae*, H1N1, seasonal flu; antibiotics; IV immune globulin
- Hypercalcemia: IV fluid and corticoid steroid, bisphosphonates (if unresponsive to hydration), calcitonin, furosemide
- Renal failure: Treatment of dehydration, hypercalcemia, and hyperuricemia; chemotherapy (e.g., vincristine, doxorubicin); alkaline diuresis; trial of plasma exchange in acute evolving renal failure; hyperviscosity syndrome; exchange of plasma (plasmapheresis)

**Assessment Points**

System	Clinical Manifestations	Signs and Symptoms	Anesthetic Implication
MS	Bone pain Pathologic fracture	Usually lumbar 95% more than one side	Positioning to prevent fracture
HEME	Bleeding and bruising Coagulopathy Normochromic normocytic anemia Capillary fragility	Secondary to thrombocytopenia Absorption of clotting factor Weakness Purpura Dark circles (raccoon-like) around eye, secondary to prolonged Valsalva	Availability of FFP and plts Increased transfusion requirements, ventilator management
METAB	Hypercalcemia  Infection Hyperviscosity	Confusion, somnolence, constipation, nausea, thirst, bone pain  Secondary to humoral immunity of normality Epistaxis Visual disturbance Carpal tunnel Headache Somnolence, bruisability	Increased fluid requirements, maintenance of adequate urine output Antibiotic coverage Preoperative: plasmapheresis, increased fluid requirement intraop Temperature maintenance to prevent microvascular sludging
CNS/PNS	Spinal cord compression Meningitis Carpal tunnel Peripheral neuropathies Stroke (hyperviscosity)	Signs of weakness and numbness of extremities	Positioning of pt Diligent use of muscle relaxants Avoidance of depolarizing muscle relaxants
RENAL	Renal insufficient/failure	Secondary to direct tubular injury Amyloidosis Involvement by plasmacytoma	Adequate hydration
RESP	Pneumonia Respiratory insufficiency	Secondary to rib fracture	Extubation problems Pneumothorax intraop
HEENT	Amyloidosis	Macroglossia Skin lesions of lips	Airway problems

**Key References:** Kyle RA, Rajkumar SV: Multiple myeloma, *N Engl J Med* 351(18):1860–1873, 2004; Palumbo A, Gay F: How to treat elderly patients with multiple myeloma: combination of therapy or sequencing, *Hematology Am Soc Hematol Educ Program* 566–577, 2009, <http://dx.doi.org/10.1182/asheducation-2009.1.566>.

**Perioperative Implications****Preoperative Preparation**

- Recombinant erythropoietin increases Hgb and decreases transfusion requirement
- Antibiotics and gammaglobulin prophylaxis

**Airway**

- May be difficult due to macroglossia

**Maintenance**

- Regional anesthesia is contraindicated due to bony lesions, coagulopathy, and neurologic deficit.
- Unpredictable pharmacokinetic of protein-bound drugs.

**Postoperative Period**

- Continue adequate hydration.

- Aggressive pulmonary toilet.
- Treat specific complication (refer to [Treatment of Complications](#) section).

**Anticipated Problems/Concerns**

- Careful positioning to prevent fractures

## Multiple Organ Dysfunction Syndrome

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**Risk**

- Most common cause of death for pts in ICU
- Incidence 11–40% of adult ICU pts
- Risk factors: (1) Severe illness at time of ICU admission; (2) severe sepsis or infection at time of ICU admission; (3) old age
- Associated with trauma, sepsis, shock, male sex, African American race, chronic health conditions, malnutrition, use of immunosuppressants

**Perioperative Risks**

- Labile hemodynamics
- Difficulty with oxygenation and ventilation
- Malnutrition
- Altered drug metabolism

**Worry About**

- Volume status
- Drug metabolism

- Antibiotic selection
- Difficulty cross-matching blood products
- Transfusion reactions

**Overview**

- MODS is a dynamic process; clinical course and causes are highly variable.

- Defined by the presence of altered organ function in an acutely ill pt such that homeostasis cannot be maintained without intervention.
- A potentially reversible physiologic derangement involving two or more organ systems not involved in the original disorder as cause for ICU admission.

### Etiology

- Septic shock is the main cause of MODS in the ICU.
- Represents a failure of homeostasis resulting from dysfunction of the neuroendocrine and immune systems.
- A combination of tissue hypoxia, exaggerated inflammatory response, and end-organ damage from

ischemia and necrosis, resulting in macrovascular and microvascular changes.

### Usual Treatment

- Requires a multimodal approach using a combination of source control, supportive care, and prevention of further complications.
- Fluid and blood products: Consider guidelines for sepsis and septic shock.
  - CVP 8–12 mmHg.
  - MAP 60–65 mmHg.
  - Hemoglobin 7.0–9.0 g/dL.
- Vasopressors and inotropic support: Consider guidelines for sepsis and septic shock.
  - Norepinephrine first line.

- Epinephrine and vasopressin may be added if necessary.
- Respiratory management: Consider guidelines for pts with ARDS.
  - Tidal volumes 6 mL/kg of ideal body weight.
  - Plateau pressure goals less than 30 cm H<sub>2</sub>O.
  - PEEP for alveolar recruitment.
- Endocrine and metabolic support:
  - Stress steroids in refractory septic shock.
  - Tight serum glucose control less than 180 mg/dL.
- Renal replacement and acid-base support: Dialysis to correct electrolyte abnormalities, acidosis, uremia, and volume overload in pts with kidney failure.
- Antimicrobial support: Initial broad spectrum antibiotics with narrowing as culture results are available.

### Assessment Points

System	Effect	Assessment by Hx	PE	Test
CNS	Delirium Altered mental status Cognitive loss	Lethargy, agitation Confusion, coma	Glasgow coma score Mental status exam	CT scan Full set of labs, nutrition markers, ABG
RESP	Abnormal gas exchange Pulm edema ALI, ARDS	Dyspnea, tachypnea Increasing O <sub>2</sub> requirement Intubation	Cyanosis, diaphoresis Rhonchi, rales, wheezing	CXR, CT scan ABG, bronchoscopy ± bronchoalveolar lavage
CV	Myocardial depression Reduced vascular tone Left ventricular failure, right ventricular failure Pulm Htn	Dyspnea Hypotension	Tachycardia, hypotension Arrhythmias—VTach, VFIB Edema, increased JVP	ECG, TTE, TEE PA cath: SvO <sub>2</sub> , CVP, PAOP Cardiac output
GI	Bleeding, stress ulcers Hepatic failure, coagulopathy Hyperbilirubinemia Cholestasis, steatosis	Bloating, diarrhea Constipation Malnutrition Acute pancreatitis	Abdominal pain Jaundice Melena, hematochezia	Albumin (low), amylase LFT PT, PTT, INR
HEME	Pancytopenia Coagulopathy DIC	Thrombocytopenia Bruising	Jaundice, pallor Petechiae	CBC + differential Leukopenia BM biopsy
RENAL/ METAB	Renal failure Lyte abnormalities Glucose intolerance	Oliguria, ATN Renal failure requiring CRRT or IHD	Edema Oliguria Anuria	Lytes Ca <sup>2+</sup> , Mg <sup>2+</sup> , phosphate, albumin, transferrin

**Key References:** Ramirez M: Multiple organ dysfunction syndrome, *Curr Probl Pediatr Adolesc Health Care* 43(10):273–277, 2013; de Montmollin E, Annane D: Year in review 2010: critical care—multiple organ dysfunction and sepsis, *Crit Care* 15(6):236, 2011.

### Perioperative Implications

#### Preoperative Preparation

- Ensure blood product availability.
- Evaluate ventilator dependency; consider traveling with the ICU ventilator.
- Thorough review of preop data (labs, cardiac evaluation, end-organ function).

#### Monitoring

- All standard intraop monitors (NIBP, temp, CO<sub>2</sub> monitoring, ECG).
- High likelihood of invasive monitors (arterial line, CVP).
- Consider intraop TEE to better assess cardiac function and volume status.
- Foley cath to monitor urine output.

#### Airway

- High likelihood pt is already on mechanical ventilation.
- Avoid alveolar derecruitment.

- Consider need for ICU ventilator if difficulty oxygenating/ventilating.

#### Preinduction/Induction

- Inhalational induction via in situ ETT if present.
- Avoid induction agents causing significant myocardial depression (propofol).
- Be prepared to provide increased hemodynamic support after addition of anesthetic agents.

#### Maintenance

- Frequent assessment of ventilation, oxygenation, hemoglobin, and acid-base equilibrium.
- Maintain ICU ventilator settings/strategy as appropriate.
- Judicious fluid management (avoid volume overload, pulmonary edema, heart failure).
- Maintain normothermia.

#### Extubation

- Likely remain on mechanical ventilation after surgery

#### Postoperative Period

- Close monitoring of oxygenation, ventilation, hemodynamic and volume status.
- Consider diuresis if excess volume administered intraop.
- Anticipate prolonged effects of sedatives and analgesics as a result of end organ failure.
- Wean vasopressors as tolerated; continue supportive care until organs are able to recover.

#### Anticipated Problems/Concerns

- Recovery from MODS can take weeks to months.
- Organs may not return to their original baseline function.
- Mortality is high; with many unanswered questions about the mechanisms causing MODS and the most effective therapeutic approach; these topics are areas of active research.