The Utility of an Interventional Radiology Trainee as a Member of the Intensive Care Unit Team

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Background

Knowledge of critical care principles is essential as the IR service has become involved in increasingly complex patient care. An ICU rotation is now a requirement of the integrated IR residency and ESIR pathway. The ICU rotation is an opportunity for the IR trainee to learn critical ICU management principles.

The Society of Interventional Radiology (SIR) Resident Fellow Student (RFS) website has developed a critical care curriculum for IR trainees, within the Patient Care Resources subsection. The curriculum is organized by topics, such as shock, mechanical ventilation, cardiac emergencies, and fluids/electrolytes.

The IR resident can serve several roles as a member of the ICU team, primarily with image analysis, POCUS, and procedures.

Arterial Blood Gas (ABG)

Diagnostic tool to evaluate the partial pressures of gas in the blood and the acid-base content. The ABG can provide insight into respiratory status, metabolic status and disturbances, and treatment response.

Definition, (normal range)	Simplified Interpretation
Measured acid-base balance of the blood (7.35-7.45)	Below 7.35: acidemia Above 7.45: alkalemia
Measured partial pressure of CO_2 in the blood (35-45mmHg)	Determines whether acidosis/alkalemia is due to a respiratory etiology. $PaCO_2$>40 with pH<7.4 = respiratory acidosis $PaCO_2$<40 with pH>7.4 = respiratory alkalosis
Measured partial pressure of O_2 in the blood (75-100mmHg)	Used to determine whether there is an abnormality with oxygenation
Calculated concentration of bicarbonate in the blood (22-26meq/L)	Can be used to determine metabolic compensation. (pH<7.4 and HCO3>26) or pH>7.4 and HCO3<24) = metabolic compensation

Arterial-Alveolar (A-A) Gradient

The A-A gradient is a measure of the difference between alveolar and arterial O_2 concentration and can narrow the differential for hypoxemia. The normal A-A gradient is 5-10mmHg

- In an ideal system, no gradient would exist since O_2 would flow freely across the alveolar membrane
- Causes of elevated gradients include shunt (pneumonia, atelectasis, cardiac), dead space ventilation (PE, air embolism), and diffusion defect (such as with interstitial lung defect)

Mechanical Ventilation and Non-Invasive Ventilation

Definitions	
V_t (Tidal Volume)	The volume delivered per respiratory cycle. 6-8mL/kg for ARDS, while 8-10mL/kg may be used for other patients
PEEP (Peak End Expiratory Pressure)	The pressure applied at the end of the expiratory phase, which keeps the alveoli open
RR (Respiratory Rate)	Number of respirations, reported per minute
F_IO_2	Percent oxygenation of inspired air, room air is 21%
I:E ratio (Inspiratory to Expiratory Ratio)	Length of inspiration relative to expiration, usually 1:2, can be increased in COPD
V_e (Minute Ventillation)	Volume of gas exchanged per minute, calculated as RR x V_t
P_{IP} (Peak Inspiratory Pressure)	Highest amount of pressure applied to the lungs during inspiration. Increases with elevated airway resistance

Common Ventilator/NIMV Modes

Mode	
AC (Assist Control)	Currently the most common ventilator setting. Each breath is either patient initiated, or at a set backup rate), up to a certain volume or pressure. AC Pressure: ventilator delivers breath until set pressure is reached. Limits peak inspiratory pressure. AC Volume: patient receives a set V_t, without a limit on peak inspiratory pressure.
SIMV (Synchronous Intermittent Mandatory Ventillation)	The ventilator allows spontaneous breaths in between a set ventilation cycle. Increased work of breathing relative to AC modes
BiPAP	Means of providing ventilatory support without an invasive artificial airway (endotracheal or tracheostomy tube). Provides supplemental inspiratory tidal volume (versus CPAP, which does not increase V_t or V_E). When inspiration is detected, inspiratory pressure (IPAP) is provided. When breath is at the end, and expiration is started, expiratory pressure (EPAP) is provided

- Noninvasive ventilation decreases respiratory work: positive pressure decreases transpulmonary pressure, increased Vt increases alveolar ventilation and CO2 elimination, PEEP recruits alveoli to improve oxygenation. When compared with invasive ventilation, NIMV decreases the risk of ventilator associated pneumonia, lung injury, and pneumothorax. The patient must be able to maintain a patent airway and spontaneous breathing.
- Regardless, the decision to initiate mechanical or noninvasive ventilation depends on the ABG and the determination of acid-base status.

Critical Care Curriculum

The SIR-RFS has developed a critical care curriculum, which can be accessed at http://rfs.sirweb.org/clinical-resources/critical-care-course/.

This curriculum was designed to reinforce clinical knowledge as residents progress through their diagnostic radiology curriuculum, and better prepare residents to be comprehensive disease specialists.

Additional course content is available at the Society of Critical Care Medicine (SCCM) at https://www.sccm.org/Home, including curriculum tailored for COVID-19 emergency response, at https://www.sccm.org/Disaster

Rounding in the ICU

The role of the IR resident varies by institution and type of ICU, with some residents rotating in SICU and others rotating in a MICU. In some instances, the resident acts as a senior, while the resident may act as an intern in other cases.

During pre-charting and pre-rounding, it is essential to review the drips/vasopressors the patient is on, ventilatory status (SBT if patient is on vent), sedation, feeds/diet, mobility/PT/OT, delirium, lines/foley (and whether they are needed), and daily labs. Radiology residents can use POCUS to evaluate cardiac function, volume status, infections/pain, and more (reviewed in the next column)

Rounding in the ICU is a collaborative effort between residents/fellows/attendings, nursing staff, respiratory therapists, pharmacists, and PT/OT. During rounds, orders, labs, imaging etc. are all discussed in a collaborative manner. The radiology resident can assist with image interpretation during rounds and provide input in additional imaging that may be needed.

Following rounding, the IR resident can help with POCUS guided procedures and diagnosis, continued image analysis, and help other members of the team with image interpretation and ordering

Lessons from the ICU

The IR resident should go into the critical care/ICU rotation with the following educational goals in mind:

- Ventilator management/NIMV, and when to use each one
- Vasopressors, vasopressor titration, and use
- Shock (cardiogenic, hemorrhagic, septic, obstructive) – pathophysiology and management
- Anticoagulation – medications and indications
- Fluids/fluid resuscitation – types of fluids and indications
- Acid/Base status, and correcting abnormalities
- Cardiac arrhythmias – detection and acute management
- Acute management of liver and renal failure
- RAAS (Richmond-Agitation-Sedation Scale)

POCUS

The IR resident is uniquely positioned to provide assistance with timely diagnosis and procedures with POCUS. POCUS applications will be more thoroughly discussed in an accompanying poster.

POCUS diagnostic applications include:

- RUSH exam
- FAST exam
- Assessment of volume status
- NSTI/Abscesses/soft tissue infections
- Pneumonia
- DVT assessment

POCUS assisted procedures include:

- Chest tube placement
- Central venous access
- Lumbar punctures
- Arterial line placement
- Joint injections
- Foreign body removal

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Critical Care Course [http://rfs.sirweb.org/clinical-resources/critical-care-course/]

Emergency Resources: COVID-19 [https://www.sccm.org/Disaster]

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