Abstract

Cardiology and cardiovascular surgery patients have historically been one of the sickest populations that physicians encounter. With the inherent compromise of the cardiac and/or respiratory system and the added complexity of a major surgical procedure, this patient group requires a demanding level of care. As innovations in the treatment of cardiac patients have prolonged life, we have encountered patients who require redo-redo-redo procedures. There has been a tremendous increase in the use of a wide variety of mechanical assist devices, transplantation procedures, robotic surgery, and hybrid approaches in which cardiac surgeons and cardiologists work in the same room on the same patient.

Against this background, there have been quite a few changes taking place in the field of critical care. This report discusses the transformations being made in blood pressure management, blood product transfusion, prevention of healthcare-associated infections, physical therapy in cardiothoracic intensive care units (ICUs), ventilatory management, and the role of intensivists in cardiothoracic ICUs.

Blood Pressure Management

Hypertension (HTN) is a very common comorbidity in patients presenting for cardiovascular surgery. It is estimated that approximately 73 million Americans have chronic HTN, and 65% of them may have uncontrolled HTN. In fact, studies have shown that up to 30–50% of patients undergoing routine cardiac surgery have perioperative HTN. Acute HTN in these patients has both a direct and indirect impact on outcomes, ranging from an increased risk for surgical bleeding to myocardial ischemia, stroke, neurocognitive dysfunction, platelet activation, and an inflammatory response leading to compromised microvascular beds. It is therefore no wonder that a survey of physicians who care for cardiac surgery patients indicated that more than 80% of patients required acute HTN treatment even though some of them did not have a history of HTN.

There are multiple points during the preoperative, intraoperative, and postoperative phases of treatment where there is an inherent risk of acute HTN, HTN urgency, and even HTN emergency — for example, preoperative anxiety and insertion of lines, induction of anesthesia, sternotomy, cross clamping of the aorta, transfer to the ICU, immediately before, during and after extubation, and in instances of inadequate sedation, pain management, or medication. Another area of investigation in acute blood pressure (BP) management is the effect of perioperative pulse pressure (PP) and its impact on coronary artery bypass graft (CABG) survival, particularly since increasing perioperative PP is being linked to poor long-term survival after CABG surgery.

Management and prevention of acute HTN episodes is vital to quality care. The first step is to anticipate and proactively treat predictable episodes of HTN, e.g., during aortic cross clamping or extubation. Prior to starting any intravenous medication to control BP, pain, anxiety, and sedation have to be addressed and appropriately treated. Acute antihypertensive therapy has two objectives, namely, the rapid onset of medication for a short duration and with minimal side effects, and the initiation of therapy to wean the patient off of intravenous (IV) antihypertensive medication, especially when they are in the ICU.

With these objectives in mind, some of the commonly used IV medications in our arsenal are nitroglycerin (GTN), Sodium Nitropusside (SNP), esmolol, nicardipine and clevidipine. Fenoldopam, hydralazine, and labetalol are not commonly used due to their profiles and side effects. SNP and GTN are commonly used IV antihypertensive agents; however, being nonselective vasodilators, they cause arterial and venous dilation, thereby potentially decreasing venous return and cardiac output and increasing the need for fluid resuscitation. The added issues of tolerance with GTN and SNP, cyanide toxicity, and rebound hypertension from SNP open the door for better agents to be used.

Esmolol is an ultra-short-acting, cardioselective, β-adrenergic blocking agent that has been extensively used in cardiac surgical patients. The rapid on-and-off mechanism of action makes it a good agent for use in acute HTN scenarios. It mainly affects the myocardium without decreasing high systemic vascular resistance (SVR), although this somewhat limits its use as a solo agent in reducing acute HTN. Nicardipine (second generation) and clevidipine (third generation, ultra-short-acting) are dihydropyridine-derivative calcium channel blockers with high vascular selectivity, making them act as arterial vasodilators. Their selective effect on decreasing SVR without affecting venous filling and/or cardiac output makes them good agents for managing acute HTN in cardiac surgical patients. Both of these agents should be used with caution in patients with heart failure, as there can be potential for exacerbation of this condition.

Tight BP control can offer some protection to these vulnerable patients, with newer pharmacological agents increasing the physician’s options for treatment. The best result may be achieved by utilizing one or a combination of two agents as indicated.
Blood Product Transfusion

More than half a million U.S. adults undergo cardiac surgical procedures each year. About 15–20% of these patients consume 80% of the blood products used annually. The annual transfusion costs of cardiac surgery are more than $500 million.

Extensive transfusion of blood products has been associated with multiple adverse effects, which include transmission of viruses, infection, volume overload, and transfusion-related acute lung injury. All of these complications lead to an increase in mortality. Blood conservation interventions are helpful. In one study, a 5-year mortality rate of 15% was calculated in transfused patients compared to only 5% in nontransfused patients.

Protocols to identify high-risk patients undergoing cardiovascular surgery should be established and implemented. Risk factors include advanced age, preoperative anemia, urgent surgery, antithrombotic therapy, clotting abnormalities, multiple comorbidities, and procedure-related variables like prolonged cardiopulmonary bypass time, reoperation, etc.

These rules are based on guidelines from the American Society of Anesthesiologists (ASA), listed in Table 1.

| ASA Guidelines on Intraoperative and Postoperative Management of Blood Loss and Transfusions |
| I. Recommendations for red blood cell transfusion |
| a. Monitor the amount of blood loss |
| b. Monitor hemoglobin or hematocrit |
| c. Monitor for the presence of inadequate perfusion and oxygenation of vital organs (e.g., blood pressure, heart rate, temperature, blood oxygen saturation) |
| d. Transfusion of allogeneic red blood cells or autologous blood (i.e., normovolemic hemodilution and intraoperative red blood cell recovery) |

| II. Recommendations for management of coagulopathy |
| a. Visual assessment of the surgical field and laboratory monitoring for coagulopathy |
| b. Transfusion of platelets |
| c. Transfusion of fresh frozen plasma |
| d. Transfusion of cryoprecipitate |
| e. Administration of drugs to treat excessive bleeding (e.g., desmopressin, topical hemostatics) |
| f. Recombinant activated factor VII |

| III. Monitoring and treatment of adverse effects of transfusions |
| a. Bacterial contamination |
| b. Transfusion-related acute lung injury |
| c. Transmission of infectious diseases |
| d. Transfusion reaction |

Table 1. American Society of Anesthesiologists (ASA) guidelines on intraoperative and postoperative management of blood loss and transfusions.
Patients with an endotracheal tube or tracheostomy should be encouraged to walk with a portable ventilator whenever appropriate and with all safety measures in place. A strong collaborative multidisciplinary approach among physicians, nurses, physical therapists, and respiratory therapists must be used in the care of these patients.

An early mobility and walking program in the cardiothoracic ICU is an approach that can potentially help patients regain their physical and psychological function and ultimately maximize functional independence.

**Ventilatory Strategies in ICU**

One of the major challenges in ICUs is managing hypoxemia or respiratory insufficiency in patients. Mechanical ventilation is the most common invasive treatment modality for acute respiratory failure, while noninvasive positive pressure ventilation (NIPPV) modes like continuous positive airway pressure or pressure support ventilation are considered the gold standard for treating chronic obstructive pulmonary disease exacerbations. NIPPV can also be used to manage mild to moderate respiratory insufficiencies.

Conventional modes of ventilation based on volume or pressure control are usually sufficient in most cases of respiratory failure. Bi-level ventilation can be used in patients who are difficult to oxygenate due to failed lungs. Other modalities that can be used in severe hypoxemia include initiation of nitric oxide and high frequency oscillatory ventilation. The updated studies in pulmonary management (e.g., the FACTT trial) and the physiological bases on which patients with acute respiratory distress syndrome are treated (e.g., use of low tidal volumes and optimum use of positive end-expiratory pressure) are important intensive care milestones.

Pulmonary hypertension management with Flolan (Epoprostenol sodium), Tracleer (bosentan), Revatio (sildenafil) and others is another evolving area. In cases of extreme hypoxemia in which mechanical ventilation alone is not helpful, support with extracorporeal membrane oxygenator (ECMO) is applied. ECMO and extracorporeal life support have been indicated as treatment for acute respiratory and cardiac failure.

**Role of Intensivist in Cardiothoracic ICU**

Since the inception of the first organized ICU in 1953, the practice of intensive care medicine has come a long way. The intensivist’s role in critical care is firmly established. The Leapfrog Group for patient safety recommends the presence of intensivists in the ICU as a standard practice. The presence of an intensivist is not only crucial for delivery of medical care in a timely fashion, but it also leads to improvement in overall care through decreased length of stay, shorter ventilator times, decreased rate of infections, avoidance of unnecessary transfusions, proper utilization of medications and antibiotics, avoidance of errors, direction of multidisciplinary rounds, coordination of care among different subspecialties, and implementation of various bundles. Intensivists are also trained to perform life-saving procedures.

By being abreast of the latest guidelines and emerging new literature, intensivists can provide state-of-the-art care. Procedures such as therapeutic hypothermia after cardiac arrest, proper ventilation in acute respiratory distress syndrome, early goal-directed therapy in sepsis, and other measures have clearly demonstrated improved outcomes in this vulnerable population, with a 30% reduction in hospital mortality and a 40% reduction in ICU mortality. Traditionally, cardiothoracic surgical ICUs have been managed directly by surgeons during postoperative care. A landmark paper...
published in 2009 showed that a full-time intensivist program in cardiothoracic surgical ICUs is associated with “reduced transfusion of blood components, decreased requirement for mechanical ventilation, and shorter hospital length of stay” (Table 2). At the Methodist DeBakey Heart & Vascular Center, 24-hour intensivist service has been in place for the last 10 years and has shown similar results, with many lives saved.

**Conclusion**

Critical care medicine is a rapidly changing field with new areas of development, research, and clinical information. Several underlying themes are critical to the care of patients in the cardiothoracic ICU. Implementation of screening and treatment guidelines facilitates delivery of consistent, quality care that is based in current clinical information. Up-to-date knowledge of the available medications, techniques, and equipment is crucial. Prevention of avoidable problems through an anticipatory approach to patient care, such as recognition of events that may trigger an episode of acute hypertension, or the use of antimicrobial prophylaxis to prevent SSIs, can go a long way towards improving patient outcomes. Familiarity with the latest evidence-based thinking on critical care issues, such as the role of transfusion management and the importance of early implementation of physical therapy among ICU patients, is also important. Intensivists with clinical knowledge and training serve not only to implement these advances in critical care but also to educate members of the ICU team about providing the best possible care to this vulnerable patient population.

**References**


