ORIGINAL ARTICLES

Cardiac Arrest in the PACU: An Analysis of Evolving Challenges for Perianesthesia Nursing

Kristen Tallman, BSN, RN, Satya Krishna Ramachandran, MD, FRCA,
Robert Christensen, MD, Denise O'Brien, MSN, RN, ACNS-BC, CPAN, CAPA, FAAN

Cardiac arrest in the PACU is a rare and poorly described event, with attendant limitations to experiential learning for the perianesthesia nurse. Good outcome from in-hospital cardiac arrest events differs partly because of variability in direct causes and clinical responses. Development of in-house training programs tailored to retain basic and advanced life support skills and enhance perianesthesia nurse responses to PACU arrests are essential to improving outcomes.

Keywords: *cardiopulmonary arrest, PACU, ACLS, case study.*
© 2011 by American Society of PeriAnesthesia Nurses

THE INCIDENCE OF cardiac arrest in the perioperative setting has been estimated as 34.6: 10,000 anesthetics.[1] A few studies are available that explore postoperative cardiopulmonary arrest (CPA) events, specifically those occurring in the postanesthesia care unit (PACU). CPA events in the PACU are rare, with only about 5% of perioperative CPA events occurring in the PACU (around 1.5 arrest events per 10,000 anesthetics).[1] Most of our current knowledge on outcomes after CPA events is derived from the National Registry of Cardiopulmonary Resuscitation (NRCPR),[2] an international database of in-hospital resuscitation events sponsored by the American Heart Association. Previous research from this group has identified several factors that may influence outcomes from CPA events, many of which have direct implications for PACU care: the time of day the event occurs,[3] weekend events,[3] and speed of response for defibrillation[4] and invasive airway placement.[5] In addition, management of CPA events by nurses trained in advanced cardiac life support (ACLS) is associated with higher survival-to-discharge rates.[6]

Patients recovering from the effects of anesthesia in the PACU likely have a preponderance of recognizable, correctable conditions. The PACU nurse is the ideal person to begin this process of recognizing the cause of the arrest and initiating its treatment. For example, in children, the most common cause of CPA is hypoxia and other respiratory causes, which the perianesthesia nurse can recognize early and treat with oxygen and airway maneuvers, even before additional help arrives.

Kristen Tallman, BSN, RN, is a Perianesthesia Staff Nurse, The University of Michigan Hospitals and Health Centers, Ann Arbor; Satya Krishna Ramachandran, MD, FRCA, is Assistant Professor in Anesthesiology and Head of UH-PACU, The University of Michigan Hospitals and Health Centers, Ann Arbor; Robert Christensen, MD, is a Lecturer in Anesthesiology, The University of Michigan Hospitals and Health Centers, Ann Arbor; and Denise O'Brien, MSN, RN, ACNS-BC, CPAN, CAPA, FAAN, is a Perianesthesia Clinical Nurse Specialist, The University of Michigan Hospitals and Health Centers, and Adjunct Clinical Instructor, School of Nursing, The University of Michigan, Ann Arbor, MI.

Address correspondence to Satya Krishna Ramachandran, UMHS Room 1H247, 1500 E Medical Center Drive, University of Michigan Medical School, Ann Arbor, MI 48109-5861; e-mail address: rsatyak@med.umich.edu.

To better describe these management issues seen with CPA events occurring in the PACU, we present two case studies of cardiac arrests in the PACU setting. These cases will explore (1) common variables that may lead to postoperative cardiac arrest, (2) the importance of early recognition of cardiac arrest, and (3) the clinical and nonclinical variables that influence successful outcome.

Case 1

A 74-year-old male with a history of coronary artery disease, mild left ventricular hypertrophy, myocardial infarction treated with percutaneous coronary intervention and stenting four years prior, hypertension controlled with beta-blocker, hypercholesterolemia, and right internal carotid artery stenosis underwent spinal anesthesia for a transurethral resection of bladder tumor. Intraoperatively, the patient complained of chest tightness, but no changes in the electrocardiogram or vital signs were noted. A few minutes after arrival to the PACU, the patient had a pulseless electrical activity (PEA) arrest. Cardiopulmonary resuscitation was immediately initiated, the patient was intubated, and a return of spontaneous circulation was noted within approximately five minutes of the onset of the arrest. The patient was then extubated and admitted to a telemetry unit on discharge from the PACU. Post-arrest chest radiograph, laboratory blood values, and electrocardiogram were within normal limits. Potential causes of the arrest included orthostatic hypotension, cardiac event, pulmonary embolism, or an adverse reaction to the indigo carmine dye given during the procedure.

The most likely cause of the PEA arrest in this scenario was the cardiovascular effect of the spinal anesthesia. Spinal anesthesia decreases systemic arterial and venous tone as a result of the sympathetic blockade. Peripheral pooling of venous blood then occurs because of vasodilation, resulting in decreased venous return to the heart, which in turn reduces the cardiac output. In addition, cardiac sympathetic blockade results in bradycardia as a result of unmasking of the effects of the vagus on the heart rate.[7] It is possible that the beta-blocker the patient was taking also diminished the response to orthostatic hypotension by limiting compensatory tachycardia.[8] Decreased arterial tone secondary to sympathetic block reduces

the systemic vascular resistance. Thus, hypotension results from both decreased systemic vascular resistance and decreased cardiac output. Orthostatic hypotension relating to premature positioning in the head-up or sitting posture could accentuate the hemodynamic effects of spinal anesthesia, resulting in cardiac arrest.[9]

Myocardial infarction, ischemia, and dysrhythmia were also possibilities in this case, especially considering this patient's history of coronary artery disease and prior myocardial infarction, but no evidence of ischemia or electrocardiogram changes were seen, and postoperative echocardiogram and cardiac enzymes were normal.

Case 2

A 62-year-old female with a history of chronic congestive heart failure (inactive at time of surgery), hypertension, hypercholesterolemia, shortness of breath/dyspnea on exertion, end-stage renal disease, hypothyroidism, chronic anemia, and obesity presented to the OR for a cadaveric kidney transplant under general anesthesia. After tracheal extubation, the patient developed acute respiratory distress in the PACU, followed by apnea and bradycardia, then cardiac arrest. Cardiopulmonary resuscitation was initiated, and the patient received intravenous epinephrine followed by chest compressions. The patient had a failed intubation attempt after failed attempts at mask ventilation. A laryngeal mask airway was placed at the time of the arrest because of inability to reintubate, and return of spontaneous circulation ensued. The patient recovered well from the event and was discharged home with no neurological deficits.

Airway obstruction immediately after extubation, which led to hypoxemia, was the most likely cause of cardiac arrest in this case. This patient was unable to be ventilated by mask or intubated at the onset of the arrest. Recognizing this, the anesthesiologist placed a laryngeal mask airway instead, and the patient was ventilated via this airway. This early back-up intervention plan allowed the patient to be oxygenated satisfactorily until return of spontaneous circulation. If this crucial step had been mismanaged, ensuing hypoxemia would have significantly reduced the likelihood of a positive outcome from the CPA event. Because the laryngeal mask airway works well as an airway

device in most patients, it is not surprising that it has been found to be a life-saving emergency airway device in many patients whose lungs could not be ventilated using a bag and conventional mask and whose trachea could not be intubated conventionally.[10]

During renal transplant surgery, a patient will endure large fluid shifts, as potentially more than 4 to 5 L of intravenous fluids are given to the patient during the intraoperative and early PACU period.[11] Taking into consideration the patient's underlying end-stage renal disease and the ability, or lack thereof, of the patient's new kidney to manage these fluids shifts, there is the potential for fluid overload to occur. This may lead to complications such as pulmonary edema and airway edema, which in turn contribute to airway obstruction. It is also important to note that the renal clearance of steroidal neuromuscular blocking agents (vecuronium, rocuronium, pancuronium) is low in patients with renal disease, thus raising the potential for prolonged weakness postoperatively.[12] All of these factors increase the likelihood of an airway-related critical event in the PACU.

Discussion

We describe two diverse CPA event scenarios in the postoperative period to explore the common issues linking the different mechanisms, management, and outcomes observed in these events. As described in these cases, the causes of postoperative CPA events are variable and often airway management issues dominate because of proximate exposure to anesthetic and opioid medications. These cases provide an opportunity for perianesthesia nurses and physicians to examine their individual roles and highlight the importance of regularly using learned resuscitation skills in the management of critical events occurring in the PACU.

First Line of Defense or On-the-Perimeter: Evaluating the Nurse's Role During Cardiac Arrest in the PACU

Current ASPAN standards state: "The professional perianesthesia nurse providing Phase I level of care will maintain a current Advanced Cardiac Life Support (ACLS) and/or Pediatric Advanced Life Support (PALS) provider status, as appropriate to the patient population served."[13] Although

nurses are educated on managing a cardiac arrest, including how to run a code, what role do nurses play in caring for the compromised patient when the time actually arises?

In the first case example, vigilance on the part of both the anesthesia provider and the perianesthesia nurse led to recognition that the patient had suffered a cardiac arrest, and appropriate treatment measures were initiated immediately. The anesthesia resident mask-ventilated the patient until intubation occurred. An anesthesia faculty physician was at the bedside, managing the code and making decisions about the care of the patient. Three nurses were involved directly with the patient: inserting intravenous lines, drawing necessary blood specimens, and providing chest compressions during cardiopulmonary resuscitation. One nurse was responsible for documentation. In the second case example, the presence of a difficult airway secondary to airway edema made intubation impossible; prompt airway management by the anesthesiologist while cardiac massage was performed by the perianesthesia team resulted in successful resuscitation.

Unlike the management during these cardiac arrests, it is more common for several physicians to surround a compromised patient in the PACU, with leadership for the code often unclear. Consequently, several conflicting orders may be given, making it difficult for the perianesthesia nurse to understand the order of importance of the tasks at hand. Thus, not infrequently, nurses remain on the perimeter. It is essential to develop a collaborative approach to patient care during critical events and early identification of roles during the CPA event. There is emerging research on the importance of leadership instructions on measures of cardiopulmonary resuscitation performance;[14] hence, there is an increasing emphasis on communication and leadership skills in ACLS training.

Long-Term Effectiveness of Resuscitation Skills

Clinical expertise requires adequate didactic knowledge but relies heavily on experiences learned during hands-on clinical management. Cardiac arrest in the PACU is a relatively rare occurrence, and this introduces limitations with purely experiential learning. What can perianesthesia

nurses do to enhance skills in managing these situations? ACLS training is effective in teaching nurses to recognize and treat cardiac arrest. The presence of at least one ACLS-trained team member at in-hospital resuscitation efforts increased both short- and long-term survival after cardiac arrest.[6,15] In addition, ACLS recertification is completed every two years, and some data exist on the waning of ACLS skills set and knowledge over time. A recent study on prevention of cardiac arrests concluded that the long-term effectiveness of these programs may decrease in the absence of continued periodic education aimed at early detection and intervention in high-risk patients.[16] It has been shown that ACLS skills degrade faster than basic life support skills, with only 30% of nurses retaining ACLS skills at three months and even fewer (14%) nurses retaining skills at 12 months after ACLS certification.[17] Taken with the evidence that survival after CPA events is worse during out-of-hours and weekend periods,[3] there are implications for perianesthesia nurses working during these periods when their clinical expertise could directly affect patient outcomes.

Implications for Perianesthesia Education

Proficiency in clinical assessment, knowledge of factors that predispose patients to cardiac arrest, along with the ability to recognize early warning signs that a patient is headed toward acute deterioration are essential. Opportunities to maintain skills necessary for successful resuscitation on a regular basis should therefore be identified. An example would be to create opportunities for maintaining mask ventilation skills. There is some evidence that early definitive management of the airway is associated with improved survival after CPA events.[5] In our perianesthesia department, nurses are encouraged to maintain bag-mask skills in patients undergoing short general anesthesia procedures such as electroconvulsive therapy. This opportunity has been made available as the result of a collaborative effort involving anesthesia providers and perianesthesia nurses. Simulation is a key component of ACLS and it is essential to include it as part of maintenance of perianesthesia skills. Nurses need to locally explore opportunities for collaborative simulation exercises with anesthesiology and surgery care providers to improve efficiency and robustness of early responses to clinical deterioration.[14]

Conclusion

In summary, we describe some of the challenges facing PACU nurses in relation to management of CPA events. Early clinical response and maintenance of resuscitation skills are essential components of good nursing practice in the PACU. Several of these concepts are transferable to other critical events seen in the PACU. On the basis of current literature, the authors recommend further research into defining collaborative clinical responses to critical incidents in the PACU.

References

1. Braz LG, Modolo NS, do Nascimento P Jr., et al. Perioperative cardiac arrest: A study of 53,718 anaesthetics over 9 yr from a Brazilian teaching hospital. *Br J Anaesth*. 2006;96:569-575.

2. Peberdy MA, Kaye W, Ornato JP, et al. Cardiopulmonary resuscitation of adults in the hospital: A report of 14,720 cardiac arrests from the National Registry of Cardiopulmonary Resuscitation. *Resuscitation*. 2003;58:297-308.

3. Peberdy MA, Ornato JP, Larkin GL, et al. Survival from in-hospital cardiac arrest during nights and weekends. *JAMA*. 2008;299:785-792.

4. Chan PS, Krumholz HM, Nichol G, et al. Delayed time to defibrillation after in-hospital cardiac arrest. *N Engl J Med*. 2008;358:9-17.

5. Wong ML, Carey S, Mader TJ, et al. Time to invasive airway placement and resuscitation outcomes after in-hospital cardiopulmonary arrest. *Resuscitation*. 2010;81:182-186.

6. Dane FC, Russell-Lindgren KS, Parish DC, et al. In-hospital resuscitation: Association between ACLS training and survival to discharge. *Resuscitation*. 2000;47:83-87.

7. Greene NM. The cardiovascular system. In: *Physiology of Spinal Anesthesia*, 3rd ed. Baltimore, MD: Williams and Wilkins; 1981:116.

8. Carpenter RL, Caplan RA, Brown DL, et al. Incidence and risk factors for side effects of spinal anesthesia. *Anesthesiology*. 1992;76:906-916.

9. Caplan RA, Ward RJ, Posner K, et al. Unexpected cardiac arrest during spinal anesthesia: A closed claims analysis of predisposing factors. *Anesthesiology*. 1988;68:5-11.

10. Cheney FW, Posner KL, Lee LA, et al. Trends in anesthesia-related death and brain damage: A closed claims analysis. *Anesthesiology*. 2006;105:1081-1086.

11. Sprung J, Kapural L, Bourke DL, et al. Anesthesia for kidney transplant surgery. *Anesthesiol Clin North Am*. 2000;18:919-951.

12. Lemmens HJ. Kidney transplantation: Recent developments and recommendations for anesthetic management. *Anesthesiol Clin North Am*. 2004;22:651-662.

13. American Society of PeriAnesthesia Nurses. *2008-2010 Standards of Perianesthesia Nursing Practice*. Cherry Hill, NJ: ASPAN; 2008.

14. Hunziker S, Buhlmann C, Tschan F, et al. Brief leadership instructions improve cardiopulmonary resuscitation in a high-fidelity simulation: A randomized controlled trial. *Crit Care Med*. 2010;38:1086-1091.

15. Moretti MA, Cesar LA, Nusbacher A, et al. Advanced cardiac life support training improves long-term survival from in-hospital cardiac arrest. *Resuscitation*. 2007;72:458-465.

16. Campello G, Granja C, Carvalho F, et al. Immediate and long-term impact of medical emergency teams on cardiac arrest prevalence and mortality: A plea for periodic basic life-support training programs. *Crit Care Med*. 2009;37:3054-3061.

17. Smith KK, Gilcreast D, Pierce K. Evaluation of staff's retention of ACLS and BLS skills. *Resuscitation*. 2008;78: 59-65.