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REVIEW

Non-Operating Room Anesthesia: Patient Selection and Special Considerations

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Abstract: Non-operating room anesthesia (NORA) represents a growing field of medicine with an increasing trend in the number of cases performed over the previous decade. As a result, anesthesia providers will need to enhance their familiarity with the resources, personnel, and environment outside of the operating room. Anesthesia delivery in NORA settings should be held with the same high-quality standards as that within the operating room. This review looks at special considerations in patient selection and the preoperative, intraoperative, and postoperative periods. In addition, there is a discussion on the unique aspects of specific NORA areas and the considerations that come with them.

Keywords: non-operating room anesthesia, local and regional anesthesia, perioperative processes, safety, clinical outcomes

Introduction

Today, medical technologies enable physicians to treat patients through minimally invasive means outside of the operating room (OR). These specialized procedures take place throughout remote locations in the hospital, consisting of endoscopy suites, cardiac catheterization labs, interventional radiology suites, and interventional pulmonary suites, among others. Not surprisingly, Nagrebetsky et al demonstrated an upward trend in the growth of NORA case volumes from 2010 to 2014.[1] For many anesthesia health care services, this growing field of non-operating room anesthesia (NORA) presents a new aspect of patient care for anesthesiology teams.

Unlike traditional operating rooms, NORA procedure rooms are built and suited to the procedures, personnel, and location specialized to perform unique medical interventions. For example, the interventional radiology suite requires a CT scanner and fluoroscopy equipment. Similarly, a magnetic resonance imaging (MRI) suite requires appropriately trained personnel who understand the dangers of electromagnetic radiation. Operationally, these environmental constraints restrict the ability to provide patient care interchangeably amongst NORA sites. In short, specific NORA procedures require specific equipment and expertise.

The nurses, proceduralists, anesthesia health care providers, and ancillary personnel staff form a complex system in NORA areas. Each team member should have a role in the design process and planning of NORA sites and operations to maximize patient safety. Before the administration of anesthesia commences, anesthesiologists must take a lead role in the care redesign process for NORA services and prioritize patient safety to ensure effective anesthesia delivery. Ultimately, anesthesiologists will be tasked to deliver anesthesia to these patients

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in NORA environments with the same quality as in the OR. The aim of this review is to analyze current literature to discuss unique aspects of specific NORA areas and the special considerations in patient selection and the perioperative period.

Perioperative Process

For anesthesiologists, one of the challenges of working in a NORA setting is the unfamiliarity of the environment. For example, the room configuration in NORA settings may not take into account additional equipment such as anesthesia machines and gas supply lines. Similarly, a procedure room could have physical limitations such as the number of electrical outlets available. Finally, there may be a scarcity of ancillary staff or staff that may not be familiar with the delivery of anesthesia in OR settings.

Another consideration is the increasing number of cases with exposure to ionizing radiation. Anesthesia providers are being increasingly exposed to radiation due to the expanding role of imaging in surgical practice. In the NORA setting, this is particularly evident in the Interventional Radiology service. Studies have shown that an anesthesiologist's exposure to radiation can exceed those of the interventionalist.[2,3] For the anesthesiologist, education and awareness of the unique practices in radiation is critical in minimizing occupational exposure to ionizing radiation. This safety issue includes the use of personal shielding (i.e. lead aprons and thyroid shields), eye protection, and maintaining distance from radiation sources.[4]

Preoperative Selection

Nagrebetsky et al determined that the mean age of patients undergoing NORA procedures was 3.5 years greater than those undergoing traditional OR procedures. Older patients tend to be more medically complex with numerous comorbidities and many patients are poor surgical candidates. Indeed, NORA sites tend to have a greater proportion of the American Society of Anesthesiologists (ASA) Physical Status Class III-V patients at 37.6% compared to 33.0% of patients for OR cases.[1] These trends suggest that it is just as important to fully assess patients undergoing NORA procedures through a thorough preoperative evaluation system. One such framework is the preoperative optimization clinic network created by Duke Medical Center to establish intraoperative risk for patients undergoing elective procedures.[5]

Recently, Duke created the first preoperative optimization clinics, which include the anemia optimization, diabetes optimization, nutrition optimization, pain optimization, and optimization for senior health. For example, the preoperative anemia clinic plays an important role in establishing a preoperative risk of anemia for elective surgeries. It enables physicians to diagnose and treat anemia to decrease transfusion rates and improve patient outcomes for elective surgeries.[6] Similarly, the diabetes preoptimization clinic can evaluate a patient's glycemic control prior to elective surgery. This medical condition is particularly important as poor intraoperative glycemic control has been demonstrated to be a risk factor for perioperative morbidity.[7] Presumably, an integrated approach allows for risk stratification, risk reduction, and care optimization prior to the day of procedure and can easily be applied to the NORA patient population.

Intraoperative Considerations

With the evolution and expansion of NORA procedures, anesthesiologists remain at the forefront to ensure patient safety and proper quality assurance measures in all settings. This includes making decisions for anesthesia equipment and monitoring devices for each procedure. Despite the development of monitoring guidelines, the uniform implementation of monitoring standards in NORA settings by non-anesthesiologists has not occurred. A study surveyed the monitoring techniques during sedations by non-anesthesia providers demonstrated inconsistent application of basic monitoring principles.[8] Regardless, the Standards for Basic Anesthetic Monitoring, created by the American Society of Anesthesiologists, applies to patients receiving monitored anesthesia care, general anesthesia, or regional anesthesia.[9]

Intraoperative monitoring in the NORA setting should be held to the same standards and qualities as monitoring in the operating room. Oxygenation should be evaluated during all anesthetics. For administration of general anesthesia, inspired gas should be measured via an anesthesia machine. For all anesthesia, blood oxygenation should be measured with pulse oximetry. Ventilation should be monitored in all patients receiving any anesthesia. Patients undergoing general anesthesia, regional anesthesia, and sedation should have the adequacy of ventilation measured through qualitative clinical signs such as chest excursion and auscultation. Quantitative measurements of volume of expired gas is highly recommended. Secondly, if an endotracheal tube or laryngeal mask is placed, the correct placement should be verified by the presence of carbon dioxide in the expiratory breath.

Continual end-tidal carbon dioxide analysis should be utilized throughout the duration of the anesthesia via capnography, capnometry, or mass spectrometry.[9] Monitoring circulation involves using continuous electrocardiography from anesthesia start to departure from the anesthetizing location. Also, arterial blood pressure should be obtained at least every five minutes and heart rate should be continuously monitored. Circulatory function can be assessed by palpation of a pulse, auscultation of heart sounds, monitoring the tracing of intraarterial pressure, or pulse oximetry. Finally, the patient's temperature should be measured during procedures in which significant changes in body temperatures are anticipated.[9]

Postoperative and Discharge Planning

Postoperative care should be managed in a similar manner as general anesthesia care after the OR. In the immediate post-operative period this includes monitoring a patient's vital signs, mental status, pain control, and airway protection. Because many of NORA procedures are minimally invasive, patients are more likely to be discharged on the same day as the operation. Each patient should be evaluated and given a Post-Anesthetic Discharge Score.[10] Holding the postoperative evaluation in NORA with the same high-quality standards as those in ambulatory surgery settings can help prevent adverse outcomes and ensures a safe discharge plan for each patient.

Post anesthesia care typically focuses on physiologic criteria that needs to be met for a safe discharge and is divided into two phases. Phase I focuses on a patient's full recovery from anesthesia and the return of vital signs to near baseline in preparation for Phase II. The Post-Anesthetic Recover Scoring System (also known as the Modified Aldrete Scoring System) can be used by PACU RNs to assess a patient's readiness for discharge to Phase II. This scoring system assigns points for criteria such as level of consciousness, respiration, circulation, oxygen saturation, and level of activity. Subsequently, Phase II focuses on preparing patients and their families/caretakers for discharge to home or an extended care environment. This includes having a discussion and understanding of postoperative instructions, medication changes, and follow-up appointments.

Perioperative Pain Management

Pain control after surgery remains challenging despite an improved understanding of the mechanism of pain. This also applies to NORA cases, where one of the most common minor adverse events is inadequate pain control.[11] Anesthesiologists are equipped with a varied toolbox to help patients in managing pain in the perioperative period. Traditional pharmacotherapy works by affecting the transduction, transmission, modulation, and perception of pain. Multimodal analgesia has been shown in multiple clinical situations to have strong efficacy in the treatment of post-operative pain.[12–14] This form of pain control works by targeting different pathways in the pain pathway to produce a synergistic effect at lower analgesic doses. In addition to the use of opioids in pain control, multimodal analgesia utilizes acetaminophen, gabapentanoids, NSAIDs, and ketamine to augment analgesia. While pharmacotherapy is traditionally used to manage pain, there are interventional techniques to provide analgesia when pharmacotherapy fails.

Regional anesthesia also offers another form of analgesia in the perioperative period. For example, regional nerve blocks with local anesthetics have been shown in orthopedic literature to decrease opioid consumption postoperatively and allow for earlier mobilization.[15] Local anesthetics may also be used in conjunction with an opioid in the management of pain through intrathecal or epidural infusions.

Interventional pain techniques can also be utilized in the chronic pain patient population, including cancer pain. In addition to neuraxial techniques, chemical neurolysis, which involves intentional injury to neurons via chemical or cryogenic methods. Neurolysis has been previously shown to significantly reduce cancer pain in patients with unresectable pancreatic cancer.[16] Other examples of neurolytic blocks can be used to target the stellate ganglion, the celiac plexus (splanchnic nerves), or the thoracic sympathetic chain.[17] While NORA allows for many more minimally invasive techniques to be utilized in the treatment of patients, anesthesiologists should remain cognizant of patient pain in the perioperative period and utilize the many tools to ensure adequate pain control.

Specific Nora Areas

Endoscopy

Endoscopies are one of the many NORA procedures requiring patient sedation. The most common procedures are esophagogastroduodenoscopy (EGD) and endoscopic retrograde cholangiopancreatography (ERCP).[18] The unique workflow of endoscopy creates special considerations for anesthesiologists in patient management and anesthesia delivery. The presence of the endoscope and its placement can cause external compression and lead to upper airway obstruction. Some endoscopic procedures require patients to be in the prone/semi-prone position, which can compromise respiratory mechanics and limit access to a patient's airway, making it potentially difficult to manage the airway during a procedure.

The use of sedatives or analgesics during endoscopy can vary widely depending on clinician preference. A topical local anesthetic such as lidocaine or benzocaine can be applied to the pharynx to aid in the insertion of the endoscope. Propofol is a popular anesthetic choice for EGD with endoscopists commonly requesting it for their procedures.[19] It has favorable qualities such as a smooth induction and maintenance followed by short recovery times with low incidences of post-procedure nausea. Another common choice includes the benzodiazepine, midazolam, either alone or in combination with an opioid like fentanyl. This combination allows for adequate sedation of patients while still allowing for rapid recovery. Sedation can diminish airway reflexes and significantly increase aspiration risk for these patients. Those who are not appropriately nil per os (NPO), or who have other gastrointestinal pathologies (i.e. small bowel obstruction and upper gastrointestinal bleed) would require a secure airway with endotracheal tube. Also, it is important to monitor for early signs of respiratory compromise from either over-sedation or aspiration with pulse oximetry, and if possible, capnography.

Interventional Pulmonology

Pulmonary medicine has expanded its toolkit of therapeutic interventions utilizing flexible or rigid bronchoscopy techniques. These procedures range from endobronchial ultrasound with transbronchial needle aspiration to balloon bronchoplasty and from airway stents to bronchoalveolar lavages. There are several preoperative considerations for interventional pulmonology to consider. Patient position during interventional pulmonology procedures typically requires hyperextension of the neck. As a result, patients should be assessed for risk factors for an unstable cervical spine (i.e. rheumatoid arthritis or maxillofacial trauma). A pre-procedural blood gas should be evaluated in some patients to establish a baseline if there is a history of significant hypoxemia and hypercarbia.[20] Some of the procedures that can be done in the interventional pulmonology suite require minimal sedation and thus may not necessitate the presence of an anesthesiologist. However, a trained anesthesia provider should be consulted when there are concerns about the patient's comorbidities or the technical demands of the procedure. More complex procedures may necessitate deeper levels of sedation and may require general anesthesia.

Successful procedures in bronchoscopy require adequate suppression of airway reflexes. Therefore, topical anesthesia with local anesthetics is important in ensuring patient comfort. Nasal anesthesia can be achieved using a combination of vasoconstricting agents (i.e. phenylephrine) and topical lidocaine. Successful blockade can also be achieved by applying a 2% lidocaine solution mixed with epinephrine-

soaked. Topical anesthesia must also be applied using a cotton ball or cotton-tipped applicator to the posterior oropharynx for conscious patients to tolerate bronchoscopy or intubation. Higher concentrations of lidocaine, such as 4% lidocaine, can be nebulized and inhaled to anesthetize the oropharynx. Targeted neural blockade of the superior laryngeal nerve (to suppress the cough reflex) and the recurrent laryngeal nerve can provide adequate oral-pharyngeal anesthesia. Ultimately, the approach to topical anesthesia, sedation, and analgesia for interventional pulmonology cases need to account for the complexity, duration, and settings of the procedures.

Interventional Cardiology

The expanding toolkit of interventional cardiology continues to evolve and expand, using catheter-based interventions to treat structural heart problems and coronary artery disease. Techniques range widely from percutaneous coronary intervention (PCI) to percutaneous transcatheter aortic valve replacement (TAVR) for patients who are poor surgical candidates.[21] Similarly, in patients with mitral regurgitation due to left ventricular failure, transcatheter mitral valve repair (TMVR) represents an alternative treatment with potentially fewer complications when compared to open mitral valve repair. Recently, Stone et al demonstrated that patients undergoing TMVR had lower rates of hospitalization and lower all-cause mortality at 24 month follow up when compared to medical management alone.[22]

Monitoring interventional cardiology patients should emphasize detection of hemodynamic change. In this dynamic environment, external defibrillator pads should be easily accessible during procedures because of the increased risk of arrythmias. Anesthesia health care providers should utilize arterial radial and central venous pressure monitoring for higher risk patients or complex procedures. Here, a continuous and frequent objective value of a patient's blood pressure provides clinicians with an early recognition of hemodynamic changes during the procedure. Similarly, transthoracic or transesophageal echocardiography can be used as an adjunct for diagnostic imaging and monitoring of cardiac function.[23]

In its infancy, TAVR was typically performed under general anesthesia with central monitoring, using a pulmonary artery catheter and transesophageal echocardiography.[23] Presumably, general anesthesia had several advantages by facilitating the positioning of the valve prothesis through patient immobility and thereby facilitating management of procedural complications.[24] However, studies have shown that mild to moderate sedation during TAVRs were associated with briefer length of stay and lower in-hospital and 30-day mortality.[25,26] These data suggest that transitioning from general anesthesia to sedation can reduce length of hospitalization and improve cost savings.

Short-acting inhalational, intravenous, and local anesthetics may be used for interventional cardiology cases and will vary based on clinician preference and patient needs. While there is no standardized anesthetic technique, it is important for the anesthesiologist and interventional cardiologist to create a plan to allow for optimal conditions for the interventional cardiologist while providing safest care during each case.

Interventional Radiology

Since the 1960s, the field of interventional radiology (IR) has made significant advances in medical technology. Today, the extent of diseases and conditions that can be treated by IR has grown considerably. Commonly used sedation strategies in IR procedures involve combinations of local anesthesia, general anesthesia, anxiolytics, opioids, and epidural anesthesia.[27] The more complex procedures tend to have patients with significant comorbidities and necessitate longer case durations. For the management of patient factors and potential procedural complications, many anesthesiologists utilize general anesthesia for patients undergoing IR procedures.

However, many IR procedures can be done under light or moderate sedation. A commonly used technique for light sedation involves peripheral nerve blockade using short- or long-acting local anesthetics. Peripheral nerve blocks can obviate the need for deep sedation or general anesthesia and can be used in a variety of IR procedures, which can be useful in patients who have significant cardiac disease or are hemodynamically unstable. For example, phrenic nerve blocks have been used for CT-guided pulmonary biopsies.[28] Similarly, paravertebral blocks can be used in biliary drainage. Other types of blocks that can be used include brachial plexus, sciatic, femoral, and intercostal nerve blocks.

An anesthesia health care provider should consider many factors when creating an anesthetic plan for each patient. The physical arrangement of equipment in the IR suite may limit access to the patient. For example, the presence of specialized equipment may require anesthesiologists to be in an unfamiliar position relative to the patient. Procedures focused in the head or neck will also make it difficult to access the airway. The procedure may require specific patient positioning or require that the patient remains motionless throughout its duration. Ulimately, a discussion between the anesthesiologist and interventional radiologist is essential to minimize complication rates in IR procedures and improve patient safety.

Radiological Imaging – Magnetic Resonance Imagine

The magnetic resonance imaging (MRI) setting presents unique challenges when compared to other NORA sites. MRI uses powerful magnetic fields and electromagnetic waves to create detailed anatomic images of soft tissue and bony structures. The magnetic field created by the MRI machine can pull any ferromagnetic object potentially causing injury to the patient and health care providers. Objects located within a patient, such as ocular implants, older implanted pacemakers, or foreign bodies, may be moved or become heated causing thermal injury; therefore additional precautions should be taken to screen patients for these objects prior to their MRI scan. Further, the electromagnetic waves have the potential to interfere with medical equipment, including most standard monitoring devices and fluid medication pumps, and thus should be used outside of the MRI area of effect or alternative equipment must be used. The practitioner may elect to utilize extension tubing to run infusions from outside MRI zone into patient, or MRI compatible pumps may be used. With the latter, the anesthesia provider must then enter the MRI room in order to change infusion rates. In the event of a code situation, the patient should be removed from the MRI room (zone 4) to zone 3. Zone 3 acts as the buffer zone where emergency scenarios such as collapsed airways, anaphylactic reactions, or cardiovascular compromise take place. Much of the necessary equipment that is not MRI safe will be located in zone 3.

Delivery of anesthesia in the MRI suite typically involves minimal sedation. Since imaging is not a noxious stimulus in itself except for the noise generated by the coils, many patients can get through a scan comfortably with light sedation. Patients who typically require anesthesia in the MRI suite may have claustrophobia, phonophobia, or an inability to remain motionless for the duration of the scan. Total intravenous anesthesia (TIVA) can be used to obtain sedation. Light sedation can be achieved with incremental doses of midazolam or fentanyl. Other hypnotics that can be used include propofol and ketamine. If necessary, hypnotics can be combined with analgesics such as remifentanil or other opioids. In cases where general anesthesia is required, induction and airway management are completed outside of the MRI suite and the anesthesia providers move the patient into the MRI machine once the airway is secured. Regardless of the technique, anesthesia health care providers should have a contingency plan to address airway access in the event respiratory complications occur.

Pediatrics

The pediatric population offers unique challenges for anesthesia providers. Anesthesiologists must pay attention to age dependent factors, pediatric comorbidities, and psychological development. Children have different anesthesia requirements than adults and a neonate will have vastly different requirements than a 17-year old teenage athlete. Providers also need to consider where a child is in his or her development. Reasoning with young children and understanding their emotions may prove to be challenging. Intraoperative monitoring of pediatric patients should follow ASA guidelines when possible. There are many uses of local or regional anesthesia in NORA settings, including, but is not limited to, pediatric cardiac catherization, lumbar punctures, and bone marrow aspiration.

Pediatric cardiac catheterization is a minimally invasive procedure that enables cardiologists to obtain information in the characterization, diagnoses, and treatment of many cardiovascular conditions. Anesthesia for cardiac catheterization is required for vascular access and for post-procedural analgesia. Mohammed et al demonstrated that deep sedation combined with caudal analgesia produced prolonged control of perioperative pain during pediatric cardiac catheterization.[29] Caudal anesthesia is an effective regional technique for sub-umbilical analgesia. The choice of local anesthetic should prioritize long duration with weak motor blockade, making 0.25% bupivacaine an ideal choice.[30]

Lumbar punctures are commonly performed in pediatric patients. Examination of the cerebrospinal fluid (CSF) provides diagnostic information for possible infection, subarachnoid hemorrhage, or neurologic conditions like Guillain-Barré. There are multiple options for analgesia and sedation during lumbar punctures. Topical anesthesia such as EMLA (lidocaine/prilocaine) cream and injected 1% lidocaine without epinephrine are typically used and each comes with their own advantages and disadvantages. Local lidocaine provides immediate pain relief, but may obscure bony landmarks creating a more difficult procedure. Topical EMLA cream can prevent this, but may require up to a one-hour delay for analgesic effect.

Bone marrow aspiration is an important technique available in the diagnosis of hematologic malignancies and is generally done outside of the operating room. During bone marrow aspiration, a needle is typically inserted into either the posterior superior iliac crest, the anterior superior iliac crest, or the anteromedial tibia. As a result, this procedure can cause significant discomfort, especially in the younger pediatric population. The standard of care involves application of a local anesthetic (either 1% or 2% lidocaine solution without epinephrine) to the marrow site.

One consideration in the pediatric population is the concern of anesthetic neurotoxicity on the developing brain.[31] While this concern continues to be a growing body of literature, there are limited studies outlining strategies to reduce exposure to medications that may possibly be harmful to a developing brain. One such technique developed to evaluate the efficacy of obtaining images without sedation is the feed and wrap technique.[32,33] The feed and wrap technique refers to the feeding and swaddling of an infant. This technique induces natural sleep in an infant to obtain quality MRI images. Studies have demonstrated that the feed and wrap technique has been a primary technique in neonatal intensive care units across the US and can be used successfully in infants undergoing MRI.[32,33]

The combination of the remote nature of NORA and the diversity of patients in the pediatric population provides a unique challenge to anesthesia providers. Anesthesiologists should consider the factors discussed above in creating an anesthesia management plan for pediatrics. When providing anesthesia to pediatric populations, providers must always be prepared in case of unexpected complications.

IVF Retrieval

In vitro fertilization (IVF) was introduced in the 1970's and it has since offered many couples with fertility issues opportunities to have children. IVF is a term that encompasses a series of procedures that involve ultrasound guided oocyte retrieval, fertilization, and subsequent transfer for a dividing embryo back into the uterus. During the oocyte retrieval, women will typically experience pain caused by the puncturing of the vaginal wall and ovary. Typically, repeated attempts are necessary for a successful procedure. Thus, it is important to maintain a comfortable setting and minimize a patient's pain and anxiety while undergoing oocyte retrieval.[34]

Retrieval of oocytes can be performed under paracervical, epidural, spinal, intravenous sedation, and general anesthesia.[35] Each technique described above have advantages and disadvantages that should be considered. Paracervical blocks can be performed with different doses of lidocaine with sedation. In a randomized, double-blind and placebo-controlled study looking at the efficacy of paracervical blocks in egg retrieval, pain scores were reduced by 38.9% and 51.4% compared with placebo and no local injection respectively.[36] Epidural anesthesia is another effective option for egg retrieval; however, it does not improve treatment outcomes in comparison to intravenous sedation.[37] Spinal anesthesia has been used as an effective method. Martin et al demonstrated that fentanyl, in addition to lidocaine with spinal anesthesia made patients more comfortable during an egg retrieval procedure than lidocaine alone.[38] Finally, intravenous sedation and general anesthesia offer anesthesiologists other techniques to ensure a successful procedure for patients. General anesthesia may make the procedure technically easier to perform for the gynecologist and more comfortable for the patient by relaxing uterine muscle tone for easier manipulation and access to the smaller ovarian follicles. The potential negative effects of anesthetic agents on IVF outcome have not been well established. Some anesthetic agents (propofol, thiopental, midazolam, fentanyl, and alfentanil) can accumulate in the follicular fluid.[34] While this bio-accumulation is indirect index of potential toxicity, more studies will need to be done to determine the likelihood of negative effects associated with these anesthetics. Ultimately, anesthesiologists should weigh patient factors and preferences and the risks and benefits of different agents and explore the safest anesthesia plan with the gynecologist and patient.

NORA Outcomes

Nagrebetsky, et al demonstrated that NORA has tangible differences in case characteristics compared to its OR counterpart.[1] For example, NORA cases include a higher mean patient age and NORA cases tend to have a higher percentage of ASA Class III-V cases. Despite the increase in NORA procedures over the past several years, there is limited data on the risk and outcomes of NORA cases. A study conducted by Chang et al looked at outcomes in interventional procedures performed outside of operating rooms and compared those to the outcomes in operating rooms. Their findings, which are based on data from the National Anesthesia Clinical Outcomes Registry (NACOR) suggest that NORA cases have a lower rate of mortality (0.02%) compared to traditional OR procedures (0.04%).[11] The most common minor adverse outcome from NORA cases were post-operative nausea/vomiting, inadequate pain control, and hemodynamic instability. The most common major adverse outcomes were serious hemodynamic instability and upgrade of care. Subcategory analysis within NORA demonstrated that cardiology and radiology procedures had an increased incidence of mortality at 0.05%.[11] This difference may be related to the tendency of these procedures to include more medically complex, sicker patients.

In addition, data from the ASA Closed Claims database suggests that anesthesia at remote locations poses significant risk to patients with over-sedation and inadequate ventilation/oxygenation during monitored anesthesia care.[39] This risk is likely related to NORA-specific challenges such as remote location, inadequate workspaces, lack of support staff, and unfamiliar equipment. In order to minimize adverse outcomes, anesthesiologists should remain vigilant and familiarize themselves with the many NORA environments at their institutions.

Future Directions/Opportunities

As previously mentioned, the field of NORA has expanded into many fields of medicine. As new medical technologies continue to evolve, more procedures, and subsequently the need for sedation, will be required outside of traditional operating room environments. Anesthesiologists will play a large role in refining techniques and strategies to provide adequate anesthesia needs in a safe and efficient manner.

Recent literature focusing on perioperative interventions to reduce cost has become increasingly popular. Cost-effectiveness research in anesthesiology has had a heavy focus on a multidisciplinary perioperative optimization.[40] Recently, Childers et al demonstrated in a study that an operating room minute costs \$36 to \$37 in California by using a top-down method which split costs into direct and indirect costs.[41] Currently, to our knowledge, the cost per minute of non-operative anesthesia time has not been well documented.

In order to look at the cost per minute of a NORA service, the University of Vermont Medical Center Departments of Anesthesiology and Cardiology conducted a study using TAVRs as a model. This study determined that the cost for TAVRs is $289.89 per minute.[42] As demonstrated, there seems to be a large discrepancy in the cost per OR minute versus a TAVR minute. There may be numerous factors in play that account for this difference. More data will be needed to analyze costs to produce cost effective interventions in NORA settings. As anesthesiologists continue to play a large role in improving perioperative medicine, continued research should include attention to the expansion of NORA services.

Author Contributions

Mitchell H. Tsai is the archival author. All authors contributed to data analysis, drafting or revising the article, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

Disclosure

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