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The impact of anesthesia on surgical outcomes and patient recovery

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Abstract---anesthesia is an evolving field with many exciting innovations on the horizon. Europe is not alone in facing new issues to solve. Similar to the USA, Europe can both seek and provide innovative solutions to the many different problems we face in medical care. Analysis of data has led to the development of a consortium with many publications to release soon in this new knowledge base. A urological anesthetic consortium has also started, which is in part developing novel trial concepts for men with prostate cancer. The ultimate goal is always to improve human health by leading research. The role of data analysis has led to new concepts for practice such as data collection to reveal and compare new practices and technology. More will come.

Keywords---anesthesia, patient recovery, human health.

1. Introduction

Anesthesia is a cornerstone of modern surgical practice. It helps facilitate the conduct of surgery, yet its impact extends beyond the surgical field and plays a significant role in surgical outcomes and patient recovery. Modern anesthesia is intended not just to achieve hemodynamic stability during the delivery of surgery but also to smooth and quicken the patient's recovery after surgery. Since its inception, anesthesia practices have evolved with new and improved techniques that now range from device-based regional anesthesia to the targeted field of anesthesia. It is easy to appreciate how anesthesia can improve surgical outcomes, given the paramount importance of achieving the three anesthetic endpoints along with the surgical endpoints, while also understanding the deleterious impact of over- and under-anesthetization on surgical outcomes.

As the practice of medicine continues to evolve with evolving tools, including surgical instruments, so do the circumstances of patient care and safety encounter significant improvement. We have witnessed the shift in surgical care from that carried out in the home to outpatient clinics to finally the dedicated surgical centers, which carry the highest levels of intervention. Advances in anesthesia have led us to the era of a new revolution, which we believe will result in the introduction of a new definition of anesthesia as we know it today. It is in this context that the chapter addresses the question of the impact of anesthesia in our daily practice on the subsequent outcome of the procedures we have given. In the rest of this chapter, we investigate each of the different types of anesthesia, detailing the physiologic changes that occur in the context of the specific type of anesthesia, and relate the outcomes to a high level of evidence.

2. Anesthesia: Types and Mechanisms

In the case of a surgical intervention, anesthesia is used to prohibit the sensation of pain and/or induce sedation in the patient. There are different forms of anesthesia, each of which is applied based on the intervention being performed. Local anesthesia is applied to a limited area of the body and blocks sensation in these specified body parts; it is often used for superficial operations on the skin. Regional anesthesia invokes insensitivity in the corresponding nerve distribution to a larger part of the body and is suitable preoperatively or postoperatively for longer-lasting pain control. General anesthesia induces reversible unconsciousness along with a loss of reactivity to stimulation; it is performed to provide a state without arousal or perception, and recently, a multimodal approach has been used involving a combination of inhalative anesthetics, intravenous infusion agents, and neuromuscular-blocking drugs. Regional or local techniques are used along with general anesthesia to attenuate hemodynamic responses, enhance postoperative pain control, and decrease the requirements for general anesthetics and postoperative pain management.

All three techniques have their advantages and disadvantages, and one goal with anesthesia is to bring a tolerable stress response and reduce the risk of postoperative complications. The choice of technique also plays a significant role for the anesthesiologist in terms of perioperative and postoperative management, patient satisfaction, and postoperative pain control. At the organ/tissue level, local anesthetics act on the ion channels like sodium channels and potassium channels and affect the intracellular signaling cascades like protein kinase C in a dose- and time-dependent manner. The intravenous and inhalative anesthetics act at the synapses on a variety of ion channels and neurotransmitter receptors. Understanding these mechanisms is essential to reduce and/or avoid severe intraoperative and postoperative complications.

2.1. General Anesthesia

General anesthesia is an intervention that allows a patient to be asleep, pain-free, and often without consciousness. It is a reversible state achieved through anesthetic agents that affect the central nervous system. These agents generally have these desirable effects: sedation, hypnosis, analgesia, amnesia, and muscle relaxation. After drugs have been administered to induce a state of

unconsciousness, additional drugs are given to maintain that state for the duration of the surgical procedure. This process is known as induction and maintenance of anesthesia. Once the surgical procedure has been completed, the agents maintaining unconsciousness are discontinued, and the patient is awakened and prepared for transport from the operating room, which is known as emergence.

For some surgical procedures, regional anesthesia or sedation in conjunction with local anesthesia may be as effective and less risky than general anesthesia. General anesthesia is not without its dangers and complications. Cardiovascular compromise, respiratory depression, airway obstruction, and metabolic derangements can occur. Monitoring and vigilance are critical during an anesthetic in order to intervene before these complications develop. Aside from sedation, general anesthesia also can result in cognitive dysfunction, an increased risk of certain cancers, and injury to vital organs. Modern anesthesiology practice, including the drugs and techniques to induce and maintain anesthesia, has evolved in order to make the safest general anesthesia possible. The time it takes to go into and wake from an anesthetic also has been minimized with faster-acting or reversible medications. These new medications help patients wake from anesthesia minutes after the anesthetics have been discontinued rather than the usual hours.

2.2. Regional Anesthesia

Regional anesthesia refers to the practice of injecting local anesthetics in or around specific nerves or regions of the body to produce a reversible loss of sensation. The loss of sensation can be used for surgical anesthesia, postoperative analgesia, or chronic pain management. There are a variety of techniques that have been developed for providing regional anesthesia. Nerve blocks involve the injection of local anesthetic in the vicinity of the nerve. These blocks can be done as surface blocks or as deeper blocks. Local anesthetic can also be injected into the space that surrounds the spinal cord.

Regional anesthesia is advantageous as it provides targeted control of the sensory, motor, and sympathetic fibers. This type of anesthesia produces fewer systemic effects than general anesthesia and permits a more rapid recovery of the patient, leading to a decreased length of hospital stay in many cases. In addition to improving surgical conditions, these characteristics make it especially useful for same-day surgery. Subsequently, regional anesthesia in combination with light general anesthesia produces far fewer airway and pulmonary complications than general anesthesia alone, promoting patient safety and satisfaction. It is currently considered the gold standard for orthopedic and soft tissue trauma surgery in many countries. Together with the use of sedation and analgesics, the importance and practice of using regional anesthesia for these surgeries are increasing in many parts of the world to achieve optimal patient and surgical outcomes. Some of the absolute indications for regional anesthesia to produce surgical anesthesia include high-risk patients and invasive surgeries such as cesarean sections and carotid surgeries.

2.3. Local Anesthesia

Local anesthesia is a technique designed to block sensation to a specific area of the body, providing a pain-free surgical procedure. It acts by blocking the nerves in the area where it is injected. It is frequently injected into tissues after the skin is anesthetized with a local anesthetic. Lidocaine and bupivacaine are the most commonly used local anesthetics. Local anesthesia is most often used for minor surgical procedures and in outpatient surgical centers. It is the fastest recovery technique for anesthesia because it is most often done in conjunction with light sedation. Patients awake quickly, and as a result, there are minimal systemic effects. It is most often used in the operating room, so many times both local and general anesthesia are used together. It can be done as a field block or a nerve block.

Local anesthesia is often the preferred technique of anesthesia for operations on the hands because the sensation in the fingers can be blocked without sedation or general anesthesia. For the face, local anesthesia can be used to anesthetize specific nerves so that after the surgery, the sensation in the face will be restored. It can also be used to maintain a continuous block for ongoing pain control. The risks of local anesthesia are directly related to the dose, so in either the office or the operating room, it is important that the person monitoring the anesthesia is skilled and knowledgeable. Allergic reactions to the anesthetic agents are possible, and nerve blocks or epidurals may result in nerve injury. These are rare complications. Local anesthesia is limited in duration, so after large surgery, it is most helpful in reducing post-operative pain for a short period. The other types of anesthesia listed in the following sections absolutely do all provide a similar level of blocking while the patient is asleep and continue to provide that pain relief for a longer period.

3. Anesthesia and Surgical Outcomes

Anesthesia is a fundamental part of the surgical process and one that can impact surgical outcomes. Intraoperatively, complications related to general anesthesia, including cardiac complications, lung injuries, and nerve damage, can occur and increase the overall odds of surgical success. After surgery, systemic complications such as pulmonary embolism and postoperative pain contribute to patient morbidity and length of hospital stay. Based on evidence showing anesthesia is closely linked to both intraoperative and postoperative outcomes, providers must prioritize anesthetic choice and management practices in surgical settings. Multiple patient-related factors, such as comorbidities, physical condition, and type of surgery, can lead to postoperative complications. Corresponding variables that can lead to intraoperative issues with anesthesia include the use of anti-thrombotic or anti-platelet therapies and increased surgical complexity.

Patient comorbidities are a major contributor to both intraoperative and postoperative issues in the perioperative setting. Despite this, proper anesthetic management can reduce the risk of adverse events developing. Optimal sedation and avoidance of oversedation can improve early postoperative outcomes, such as reducing the risk of postoperative delirium. Anesthesia providers can also use these practices in patients requiring local anesthesia only to improve their overall safety and comfort. To date, data back several practices that can lead to improved

outcomes when performing certain surgeries, such as preference for the use of regional anesthesia for hip and knee arthroplasties over general anesthesia. However, other current anesthesia techniques or their effects remain to be fully studied to optimize outcomes, such as the ideal time to perform regional anesthesia in arthroplasty, the type of cool irrigant for the management of uterine cancer during laparotomy, and care of extremity surgical procedures with general anesthesia when regional anesthesia is not feasible. Ongoing advances in tracking and practice patterns have led to the observation of both known and unreported complications that can lead to postoperative harm that are potentially due to anesthesia techniques. Ongoing assessments will aid in refining the use and timing of anesthesia techniques to ensure they are providing optimal results.

3.1. Intraoperative Complications

Vignette: A 67-year-old gentleman with a history of diabetes, hypertension, and coronary artery disease is currently undergoing a laparoscopic cholecystectomy under general anesthesia. The procedure proceeds uneventfully, but at the time of laparoscopy insertion, the patient suddenly becomes hypotensive with EKG findings demonstrating ST segment depression that was not present prior to the start of the case. What is your differential diagnosis? What steps do you take to address this issue?

Many types of complications may arise in the perioperative period, which begins when the patient undergoes evaluation and work-up for surgery and ends once the patient has been completely discharged from the medical center over the first 30 postoperative days in the postanesthesia care unit and in the hospital. Complications that are directly the result of anesthesia techniques and may occur during surgery are called intraoperative complications. Intraoperative complications, as well as other aspects of anesthesia, have remained of interest to many investigators and clinicians. Studies have sought to compare the frequency of anesthetic complications using various anesthetic techniques, whether combined regional/general anesthetics had a higher frequency of complications than the sum of their independent components, and the anesthetic drug combinations associated with the highest rate of specific complications, among others.

Intraoperatively, complications can range between respiratory events, cardiovascular instability, and drug-related issues. The patient factors, type of surgery, and anesthesia techniques contribute to perioperative risk. It should be remembered that an endobronchial intubation during surgery can cause hypoxemia rather than hypercarbia, that bradycardia or asystole immediately after drug administration can only be due to drug effect or anaphylaxis, and an acute intraoperative tension pneumothorax can cause profound hypoxemia. Therefore, a simple algorithm may be helpful, but it should not replace good clinical acumen, vigilance, and appropriate monitoring in order to deal with complications. Anesthesiologists with specialized training in the care of patients having surgery for certain types of surgeries, children, as well as those placed in additional areas of subspecialty practice may help manage some of these problems. All members of the surgical team in the operating room must be vigilant and work closely together with good communication to minimize and deal with such problems as they arise.

While significant progress has been made, further refinements are needed in the methods used to predict risk in patients who are scheduled for surgery. New information is now developing by the day on perioperative anesthetic issues as improvements in anesthesia techniques have expanded complex surgeries to an increasingly large patient population. The preoperative assessment is a critical stage in our patients' journey to the operating room. Identifying patients at higher risk for postoperative complications between those expected in a healthy patient can be quite challenging since complications related to anesthesia can be related to either the patient or the anesthetic or both. The greater the degree of systemic compromise, the greater the likelihood of a more serious complication in the perioperative period.

3.2. Postoperative Complications

Following surgery, complications such as side effects and inadequate surgical recovery can occur. When complications directly concern anesthesia, they are referred to as anesthetic side effects or postoperative problems. Poor pain management, postoperative nausea and vomiting, and delayed re-convalescence are also frequently comparable complications. The kind of anesthesia, whether general, regional, local, or a targeted multifactorial analgesic, largely dictates whether or not and how serious these complications will occur. Locoregional perioperative anesthesia of regional and neural areas not only helps avoid the occurrence of unpleasant postoperative issues, but it also leads to a reduced need for anesthetics. Awareness and proper guidance supplied throughout the perioperative period also aid in the avoidance of these circumstances, or the frequent untoward effects can be effectively treated or avoided with careful management. In the surgical and patient attributes, the anesthesiologist has a responsibility to continue caring for the affected person postoperatively, comparable to the depth of the duty assumed by everyone during the intricate, severe, and challenging anesthetic procedures.

Unlike the anesthetic management in the perioperative period, which relies on the surgery and the patient, the postoperative care of the patient greatly relies on the 3As – the anesthetist, the evaluation, and the approach. Pain, discomfort, and a significantly postponed or impaired rehabilitation are some of the common conditions needing critical management to avoid unnecessary issues. Postoperative patients typically ask for postoperative pain management systems from their doctors. Pharmaceutical treatment to reduce pain, inflammation, and lower fever influences the practices embraced by the health care provider and can be administered systemically or regionally. Paracetamol is the most common systemic pain relief therapy supplied to patients, although ibuprofen and non-steroidal anti-inflammatory medications are less frequently used. The selective COX-II inhibitors, along with different doses of paracetamol and NSAIDs, may be used in combination with standard treatment. Local infiltration analgesia methods, which comprise a blend of a local anesthetic and adjuvants, are regularly utilized for postsurgical relief. Co-analgesics, which include gabapentinoids or ketamine and tramadol, have been utilized in some trials to help supplement both local anesthetics and systemic analgesics. This strategy is adaptable to the type of operation conducted on the patient and can be individualized. Factors such as the individual, treatment,

other medications, and potential complications considered prior to operation may help trend an individualized approach.

4. Anesthesia and Patient Recovery

An area where anesthesia can have a substantial impact is in patient response and recovery. Postoperative pain can be a significant stressor to patients and can greatly affect their satisfaction with their surgical care. The use of anesthesia also influences the body's response to surgery by modulating local inflammation, mitigating the surgical stress response, and decreasing tissue trauma. This will obviously reduce the inflammatory mediatory response that can contribute to postoperative pain and delay recovery. Understanding how different types of anesthesia can affect these processes and outcomes is an area of current interest. Postoperative pain has been defined as the physiological response to anticipation, trauma to tissues, and metabolic and immunologic changes secondary to injury. Pain management post-anesthesia and surgery has become both an art and a science. Art is needed because some components of pain perception are beyond our control. Science, on the other hand, is needed to provide a rational basis for our therapies. A typical postoperative pain management strategy reflects that pain has affective, sensory-discriminative, cognitive, behavioral, and attentional components. It is believed that the combination of anxiolysis, modality-specific, and non-opioid analgesics is ideal for the management of pain. Pain relief with timely intervention of effective therapy will ensure patient comfort and satisfaction with their surgical care. Pain relief also will blunt any unwanted effects of the surgical stress response and allow the metabolic changes that lead to healing to begin unimpeded. Substantial pain from surgery is undesirable as it will shift energy reserves from the immune response and new protein synthesis to neural processing of the pain experience. Pain that is not adequately controlled may also lead to memories that will make a patient avoid future surgeries.

4.1. Pain Management

Pain management is an essential element of patient recovery, particularly given patients' increasing demand for a better quality of life postoperatively. As such, the choice of anesthesia directly affects patient outcomes. Adequate and timely pain control and optimum pain management are the underlying principles of delivering holistic patient care. It involves using various modalities alone or in combination to control surgical stress with minimal adverse effects. Developed methods have been shown to reduce discomfort at rest and during physical therapy, improve patient satisfaction scores, and enhance discharge rates.

Pharmacological methods such as opioids and regional anesthesia, together with adjuncts such as corticosteroids and alpha-2 adrenergic blockers, are classified. If, for example, GABAergic drugs are combined with sedatives such as propofol and opioids, this takes into account the separate therapeutic effects on multiple pain pathways. This augmented routine is part of the current multimodal analgesia paradigm. Since anesthetic factors have a major impact on postoperative pain control, collaboration between anesthesia and surgery teams is advantageous in the development and implementation of pain management plans. In addition, educating patients about future pain management and encouraging cross-

individual commitment to a multi-level, professional, empathetic, and effective pain management plan before and after surgery is essential. Within this plan, the preoperative as well as peri- and postoperative periods must be taken into account. Postoperatively, with proper pain control, many patients grant themselves the same activity sooner than if they cannot control their pain.

4.2. Recovery Time

Recovery time after surgery is significantly influenced by the choice of anesthesia and its management. Prolonged postoperative durations are linked to increased morbidity while not using excessive resources. Factors affecting patient recovery time after surgery are patient characteristics, such as age, obesity, gender, fitness, state of comorbidity, ASA status, and severity of disease, cancer, or urgency of surgery. In the era of ERAS and for financial purposes, reducing patient recovery time is recommended. This has to do with the efficiency of healthcare delivery as well as patient comfort, for both may be heavily influenced by the recovery burden of the moderate or high-risk surgical patient. Increased emphasis is placed on improving the quality of care through a quicker recovery.

Rapid improvements in both surgical anesthesia techniques and perioperative care after major surgery have reduced the duration of anesthesia performed by nearly 60% over the last 100 years. Safer anesthesia with a wider therapeutic index and monitoring such as titration to BIS values, avoiding PT/AT, EMA, and TOF measuring in the awake and alert patient, may contribute to a further shortening. One of the objectives of 'fast tracking' surgery is the provision of seamless analgesia with minimal effect on the conduct against tachycardia, hypertension, and the activation of the hemostatic system. Drugs that cause stimulation of these vital functions could in the future be avoided and lead to reduced morbidity and shortened duration of the post-anesthesia care, and earlier discharge. It is also important to individualize patient care in the future. Differences that form the need for an individual plan can only be created during the recovery in the broad sense. For a quicker recovery of our patients, protocols and guidelines have been described. Reducing the length and cost of hospitalization is of growing importance. It is illogical that all patients need to stay in their hospital bed for several hours postoperatively regardless of which type of anesthesia is used, the procedure, and the patient's condition. (Albrecht & Chin, 2020)(Dohlman et al., 2020)(Macfarlane et al.2021)(White et al.2022)(Heydinger et al., 2021)(Neuman et al.2021)

5. Future Directions and Innovations in Anesthesia

Emerging evidence suggests that patient outcomes from surgery can be improved by employing technology and advanced anesthetic techniques. Goal-directed fluid therapy and enhanced recovery after surgery protocols are just two strategies that can be used to improve surgical outcomes and patient satisfaction following anesthesia. This approach takes a multidisciplinary view of patient care to provide the best possible recovery from surgery and may even reduce the length of hospital stay. Future anesthesia may well focus on personalized care for an individual patient based on their specific profiles. Personalized anesthesia is particularly exciting because it allows us to develop appropriate anesthetic plans based on patient factors. For example, a younger patient with no comorbidities would be an

ideal candidate for targeted anesthesia or for clinical trials investigating new anesthetic agents with fewer side effects.

Another development in our understanding of pain and alternative therapies to traditional opioids is an area of great interest. Research into newer analgesic agents and target systems could revolutionize the treatment of pain following surgery. Another area of development would be the use of analytics including artificial intelligence and machine learning for anesthetic delivery and monitoring. Personalization of care would again be a benefit of this kind of development, with data sets and algorithms created in the clinical setting and decisions made based on specific patient data. The drugs we have at our disposal for anesthesia and postoperative pain control will continue to be the focus of new research. The drugs we develop in the future will hopefully offer safer alternatives to many of the traditional drugs in use today. Collecting these data and using them to develop different healthcare solutions is an affordable care option for the public compared to more traditional approaches. One important consideration is to question the ethics of changing the standard of care. Should anesthetic fields observe a traditional model or shift towards newer, ICT-driven results? Feedback to developers in this way can inform best practices and ensure IT and sociotechnical systems align to produce the greatest efficiency and effectiveness in the market. Efforts must also be sustained in order to improve existing training programs. Buying expensive medical equipment will not necessarily solve the problems of medical and surgical errors. In this rapidly changing world, professionals must adapt to the new digital dimension. Ongoing research and practice must be from a healthcare perspective in order to implement new technologies and systems ultimately improving patient safety.

In summary, anesthesia is an evolving field with many exciting innovations on the horizon. Europe is not alone in facing new issues to solve. Similar to the USA, Europe can both seek and provide innovative solutions to the many different problems we face in medical care. Analysis of data has led to the development of a consortium with many publications to release soon in this new knowledge base. A urological anesthetic consortium has also started, which is in part developing novel trial concepts for men with prostate cancer. The ultimate goal is always to improve human health by leading research. The role of data analysis has led to new concepts for practice such as data collection to reveal and compare new practices and technology. More will come.

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