Principles of Neurophysiological Assessment, Mapping, and Monitoring

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Foreword

In the constantly evolving realm of fundamental, translational, and clinical medical sciences, it is imperative that cutting-edge knowledge be synthetized and transmitted clearly and accurately to healthcare providers. This book deals with intraoperative monitoring, a field that has evolved rapidly in the last few decades. Intraoperative neurophysiologic monitoring has become an important area because it provides functional information in real time during surgery, thus benefiting patients and serving as an essential guideline for surgeons in the prevention of neurological damage. Therefore, multidisciplinary knowledge spanning neurophysiology, anesthesiology, neurology, and neurosurgery is enriching this field due to the creation of a two-way channel of communication, from the lab bench to the clinic and from the patient to the lab. This includes monitoring of the electrical activity of the nervous system (auditory and somatosensory evoked potentials and EEG).

That is where this book comes in: *Principles of Neurophysiological Assessment, Mapping, and Monitoring*. Based on their combined knowledge and experience in intraoperative neurophysiologic monitoring and neurophysiology in neurosurgery, Drs. Alan David Kaye and Scott Francis Davis have assembled a textbook that is a well-integrated blend of contemporary fundamental and clinical sciences aimed at clinicians who monitor the function of the nervous system during surgery. Dr. Kaye is an outstanding leader of the academic program in anesthesiology at the Louisiana State University Health Sciences Center (LSUHSC), New Orleans, and Dr. Davis has distinguished himself, due to his talent, drive, and motivation, since he was a graduate student in the LSUHSC Interdisciplinary Graduate Program.

While there are advanced texts leveled at neurophysiologists, surgeons, and residents alike, there are few that expound upon the basics of intraoperative neurophysiologic monitoring in such a way that those just entering the study can understand the underlying principles of this field. At the same time, the way that the materials are presented here also will be very useful to experienced specialists. The contributors to this book provide the brick and mortar that lay the foundations of neurophysiologic monitoring, which will benefit new technologists all the way to neurophysiologists and neurosurgeons.

Not unlike Wilder Penfield, who pioneered seminal brain mapping studies, this book seeks to provide a comprehensive guide to students just beginning their journey and experts searching for an excellent reference to other aspects of intraoperative neurophysiologic monitoring and neurophysiology in neurosurgery.

New Orleans, LA, USA Nicolas G. Bazan

Preface

Electrophysiological stimulation and recording was used in the operating room by researchers as early as the 1930s to study the functional organization of the cerebral cortex [1–4]. Seminal studies by scientists such as Penfield and Celesia led to our modern understanding of the functional organization of the cerebral cortex. This early work paved the way for further investigations into the utility of intraoperative electrophysiological recordings in protecting the nervous system during surgery. By the 1960s, facial nerve stimulation was being used during surgery for vestibular schwannoma to prevent postoperative facial nerve palsies [5, 6].

In the 1980s, brainstem auditory evoked potentials and somatosensory evoked potentials were introduced to protect the spinal cord and brainstem during surgery [7–9]. The application of intraoperative monitoring modalities began to cross into specialties other than neurosurgery such as orthopedics and ENT. This technology was still mostly available only at larger academic medical centers.

The 1990s ushered in a stage of rapid growth for the field of intraoperative monitoring. The advent of transcranial electrical stimulation provided a new means for monitoring the motor system during surgery [10]. Intraoperative monitoring began to move from the academic centers into community hospitals. This was made possible by the entry of private enterprise into the field, and with this growth came the demand for a skilled workforce. Traditionally dominated by physicians and neurophysiologists, the field now incorporated skilled technologists under the supervision of one of the physicians or PhD neurophysiologists.

Continued growth led to two new challenges in the delivery of IOM services to new markets: lack of formal training for IOM technologists and insufficient professional oversight. To a great extent, these problems are still present today. Someone interested in becoming an IOM technologist generally has to find a position with a company that has a quality training program. Corporate training programs range from the "see one, do one, teach one" model all the way to rigorous academic-quality programs. There are efforts to establish an academic path for people wanting to become IOM technologists. With job growth set to outpace qualified technologists, this problem will force a solution.

The problem of insufficient oversight was temporarily solved in the 1990s and early 2000s with the advent of real-time remote monitoring (RTM) allowing the physician or neurophysiologist to monitor a case (or multiple cases simultaneously) and provide interpretation to the technologist and surgeon in real time. Once considered a luxury, RTM has become a community standard available nationwide. Currently only physicians are reimbursed for RTM, but a changing reimbursement climate and shortage of qualified physicians are posing a danger to patient access to RTM nationwide. In time it is likely that nonphysician providers, such as PhD neurophysiologists, will be reimbursed for providing RTM services.

Intraoperative monitoring is now entering a new and critical phase of growth. Emerging technology and advances in neuroscience research are creating exciting opportunities for the field of IOM. Neurophysiologists are working alongside neurosurgeons to map subcortical brain structures and identify therapeutic targets for treatment of movement and affective disorders. New minimally invasive surgical procedures are making recovery times shorter and reducing postoperative pain. These new procedures require different approaches to spinal cord and nerve root monitoring that will ultimately make spine surgery even safer. Finally, we are gaining more knowledge of basic neurophysiological function of patients under general anesthesia that will lead to new ways to monitor the nervous system. The study of spinal reflexes in the anesthetized patient is one promising example of the ongoing research that makes IOM an exciting and dynamic field.

The field of intraoperative monitoring requires foundational knowledge of several disciplines such as anatomy, physiology, surgery, electronics and instrumentation, and anesthesia. This book was conceived as a resource for a diverse audience. Primarily intended as a textbook for use in academic courses in intraoperative monitoring or in corporate training programs, this book is unique in that it provides a comprehensive section on anatomy and cellular neurophysiology relevant to the IOM clinician. This book is intended to be highly "reader friendly" and attempts to provide the didactic and practical principles needed for a new IOM clinician, experienced clinicians, anesthesiologists, and surgeons interested in intraoperative monitoring. Physicians, neurophysiologists, and technologists preparing for board exams will also find this text very useful. Basic didactic concepts presented in early chapters are brought together into practical chapters on intraoperative monitoring and mapping. Chapters covering electrophysiological assessment of spinal cord pathology and the treatment of pain round out this book and will be highly useful to anesthesiologists and residents interested in diagnosing and treating chronic pain.

New Orleans, LA, USA Alan David Kaye
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This book is dedicated to my incredibly talented wife, Robin, and our four perfect children (Georgia Rose, R. J., Scottie, and Graham). You are the light of my life and the source of all of my pride. Last, but not least, I dedicate my work *Ad maiorem Dei gloriam!*

New Orleans, LA, USA Scott Francis Davis

I would like to thank Scott Francis Davis for coming in my office and discussing his hopes to one day write the book presented here. I wish to thank my true love and wife, Kim, and my children, Aaron and Rachel. I want to thank my mother for stimulating and nurturing my interest in medicine, which began when she had lumbar disc surgery in 1975. Finally, I wish to thank my colleagues at LSU and Tulane Schools of Medicine for their support over the past 23 years.

New Orleans, LA, USA Alan David Kaye

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Introduction to the Operating Room

1

Kristin Krasowski Reed and Scott Francis Davis

Introduction

The IOM clinician is part of a patient care team that consists of the surgeon, nurses, technologists, and anesthesiologists. You will recognize that each team member has a specific role to fulfill in order to provide the best care for the patient. As an IOM clinician, you will spend the majority of your working hours inside a hospital operating room (OR). The OR is a unique environment that may take some time getting used to. You will encounter different types of equipment as well as rules for navigating the space and interacting with other team members. This chapter will introduce you to the operating room along with the equipment and personnel you will encounter there.

Going to the Hospital

Going to a new hospital can be a daunting task for even the seasoned neuromonitoring clinician. There are many hurdles that you must jump before you even meet the patient, from finding the appropriate place to park to navigating your way to the OR suite. Luckily, most hospitals have a similar layout.

Your journey begins with actually finding the hospital. You may often find yourself driving to a hospital in a new city in the early morning darkness. As you get closer, there are road signs that will help you to navigate the rest of the way in. These road signs are blue squares with a single white H (Fig. 1.1). Once you've found the hospital, you have to find an appropriate place to park. Dedicated patient or employee parking is often not permissible since the neuromonitoring service is considered a contracted vendor and not actual employees of the hospital. If you find dedicated visitor sections of the parking, that would be the best choice.

If this is your first trip to a new hospital, be familiar with the entry requirements for the facility you are visiting. For example, do you have to sign in at a security desk? Does the hospital use a third-party vendor credentialing service that has a self-service kiosk for you to obtain a badge? Maybe you need to visit the hospital biomed department to have your machine checked before bringing it to the OR. When in doubt, ask for assistance from hospital volunteers or security personnel. Once you have obtained a badge and had your machine checked (if required), you are on the lookout for the operating room. Begin by following signs to pre-op, post-op, or surgery.

The OR suite has multiple areas that you will learn to navigate, including the individual

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Fig. 1.1 An example of a road sign directing traffic toward the nearest hospital

operating rooms. Most operating suites have a similar layout (Fig. 1.2). Among the areas you will encounter are changing rooms (usually connected to a staff lounge), a control desk (also called the front desk or bridge), offices, a sub-sterile corridor connecting the individual operating rooms, and pre- and post-op holding areas. It is important to become familiar with which areas are restricted to personnel in scrub attire and which are not. These areas are often indicated with either a sign or a strip of red tape on the floor.

When first entering the OR suite, the first room you may come across is the locker room. Inside the locker room, scrub pants and tops will be available. You should arrive in professional clothing and change into hospital-provided scrubs upon entering the operating suite. Sometimes you will find empty lockers for visitor use. If you are concerned about the security of your valuables, you may wish to carry your own padlock. There is often an exit door into the OR corridor once you are dressed out in scrubs. Either inside or just outside the locker room will be bins with scrub hats and protective shoe covers. In the OR corridors, scrubs, hats, and shoe coverings are required; however, masks are not needed until entering the sub-sterile corridor or an OR that has open sterile equipment or a surgical procedure in progress.

Once dressed out, the first stop you should make is to the control desk to look at the board. The board may be either a traditional whiteboard or more sophisticated panel of LCD monitors. No matter if simple or sophisticated, the board contains all of the information on surgical procedures being performed in the operating suite that day. It will show information on the scheduled start time, room number, the procedure, and the surgeon. The board may indicate the current status of the procedure (in progress, delayed, etc.). You should always check the information on the board against the information you had prior to coming to the hospital. It is common to discover that the cervical fusion you thought you were monitoring is really a lumbar fusion or even that your case has cancelled or been delayed.

Now you are ready to go back to the room. If there is a sub-sterile corridor, you should enter the room from here. This is to limit the entry of air from the non-sterile corridors, which are generally only used to bring the patient into the room. If possible, get a cart and set your machine up in the sub-sterile area and bring it into the OR, leaving your machine case in the corridor. Remember your machine case has been sitting in your house and car as well as rolled through the parking lot. It might have dirt, pet dander, etc. on it. No one wants your cat's hair contaminating the room. If you are the first member of the OR team entering the OR, you do not necessarily have to have a mask on as nothing in the room is sterile yet. Once the equipment to be used during the surgery has been opened, all members of the team must have their masks on. This equipment is easily recognizable by the blue sterile packaging it comes in. Remember: in the OR blue equals sterile, which means that masks should be on and covering your face.

The individual operating rooms are well lit, slightly cooled, and humidity controlled to decrease the spread of infection. They have specialized air handlers that filter air and keep the pressure slightly raised. The positive pressure environment serves to push air out of the room when the door is opened in order to keep germs and insects out of the room.

Once inside the operating room, you will see many pieces of equipment. The room is set up strategically to maximize efficiency and minimize the

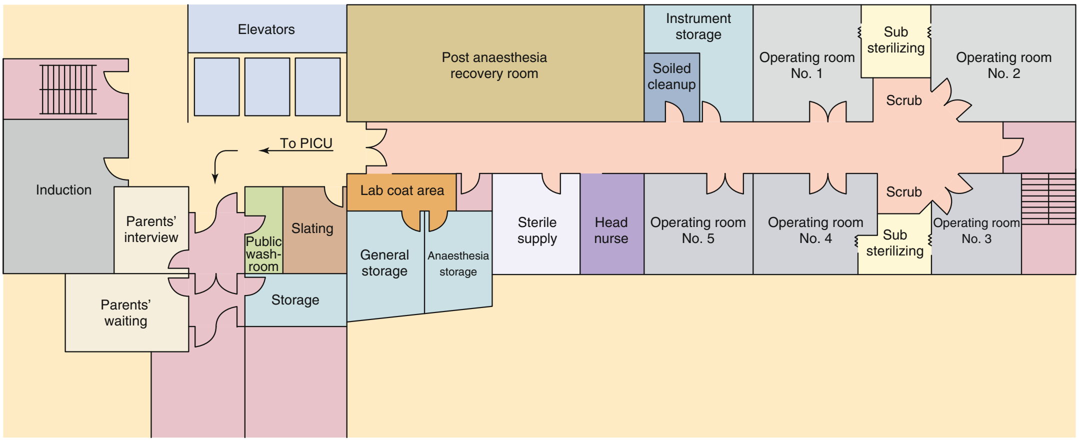

Fig. 1.2 Floor plan showing the layout of a typical operating suite

chance for infection. For example, the sterile table of instruments will be located on the opposite side of the room from the doorway. The operating table (sometimes called the bed) is usually in the middle of the room, and the anesthesia machine is located at the head of the operating table. Microscopes, neural navigation, and X-ray equipment (C-arms and O-arms) remain against the walls. They need to be brought in close to the bed. Remember that these larger items will be covered with a sterile drape before being used. It is permissible to touch these items before they are draped but not after.

When you first enter the OR, you should identify an appropriate place to set up and monitor the case. Always introduce yourself to the circulating nurse and politely ask where you should set up. Generally it is best to set up adjacent to the anesthesia machine. This location gives you good access to the patient as well as to the anesthesiologist or CRNA. By monitoring from this location, you avoid having to get up from your station to gather anesthesia information.

Pre- and Post-op Areas

Prior to being brought back to the operating room, the patient is held in a pre-op staging area. The period of time before the patient is brought to the room is a hectic one with all members of the team trying to gain access to the patient before the patient is anesthetized. It is during this time that consents for treatment (including monitoring) and past medical and surgical histories are obtained. The neuromonitoring clinician uses this opportunity to confirm the surgical procedure and levels as well as to identify any pre-existing pathologies that may affect the monitoring data. At the conclusion of the procedure, the patient is brought to the postoperative area, also called the recovery room. It is here that the monitoring clinician will assess the patient's postoperative neurological status.

The Surgical Team

Surgery should be considered a team sport. There is a unique cultural undercurrent that is present in the operating room that you will find no matter what part of the country you are working in. The surgeon is first and foremost the team captain. All members of the team must carry out their responsibilities with attention to the wishes of the surgeon. To help ensure consistency, each surgeon has preference cards that are reviewed by the surgical staff prior to the start of the procedure. Preference cards have information such as how the surgeon likes the patient positioned and prepped along with information on types of instruments that should be available.

If the surgeon is the team captain, the circulating nurse is the team manager. The role of the circulating nurse is to make sure the procedure runs safely and smoothly. The circulating nurse is in charge of how the room is to be set up (including on where the neuromonitoring team will do their job), prepping the patient, and making sure that all of the equipment, instruments, and supplies are readily available during the procedure. The circulator also performs the time out prior to incision. The time out is a pause in activity allowing the team to confirm that the correct patient is in the room, the correct site of surgery has been marked, and if there are any known drug allergies. The circulating nurse is responsible for the medical care of the patient until the recovery room staff takes over.

The anesthesiologist is a physician responsible for putting the patient to sleep, maintaining the patient in an anesthetized state during the procedure, and waking the patient up after surgery. The anesthesiologist is responsible for the medical care of the anesthetized patient. An anesthesiologist may be responsible for multiple rooms simultaneously and must be assisted by a member of the anesthesia team that is always present with the patient. This may be an anesthesiology resident (an anesthesiologist in training) or a nurse anesthetist. A nurse anesthetist is known as a CRNA, which stands for certified registered nurse anesthetist. The neuromonitoring team must communicate effectively with the anesthesia team. The choice of anesthetic may greatly affect the success of neuromonitoring. It is important to remember that the priority lies with the anesthesiologist keeping the patient anesthetized and medically stable. With that in mind, it is paramount that the neuromonitoring team communicates clearly with the anesthesia team and shows deference to their critical responsibilities.

The surgical technologist or scrub tech is responsible for sterilizing the instruments and setting up the instrument table. During the procedure the scrub tech will hand the surgeon instruments and is responsible for counting supplies both before and after the procedure. This safeguard ensures nothing is left inside the operative site. The scrub tech may be a nurse but may be a graduate of a 2-year training program in surgical technology.

Intraoperative imaging techniques are often used during spine surgery to assist the surgeon with identifying the correct level and determining the adequacy of instrumentation. A radiology technologist is present in the room to operate the imaging equipment. The most commonly encountered imaging equipment in the OR is the C-arm. Since there may be multiple rooms requiring the services of the radiology tech, this person may come and go during the procedure.

If hardware or other implants are to be used during the surgery, there will be a representative (often called a "rep") in the room that is trained in the use of the hardware or implants. This person is a hybrid sales person/technician and is usually not authorized to lay hands on the patient. Instead this person guides the surgeon in the appropriate use of the product and is there to troubleshoot issues that arise with the use of the product.

Each member of the team has an important role to play in ensuring a safe and effective surgery. This team approach often results in a mutual respect among the members of the team. It is common to see all team members thanking each other at the conclusion of a surgical procedure (Fig. 1.3).

Commonly Encountered Equipment

The Operating Table

There are several different types of operating tables to meet the requirements for different surgical procedures. Most share some common features. The ability to adjust the height of the bed as well as its position is a critical feature. The OR table is one of the most common sources of 60 Hz noise seen in IOM recordings. The table may be unplugged when its controls are not being used in order to eliminate the source of noise (Fig. 1.4).

Electrosurgical Unit

The electrosurgical unit (ESU) is also called the electrocautery equipment. This equipment uses high-frequency current to cut through the skin and cauterize bleeding vessels. There are two common types of ESUs, a monopolar and a bipolar. Use of the ESU introduces a high-frequency artifact into the IOM recording that is difficult to average out. The IOM machine should be paused during cautery (Fig. 1.5).

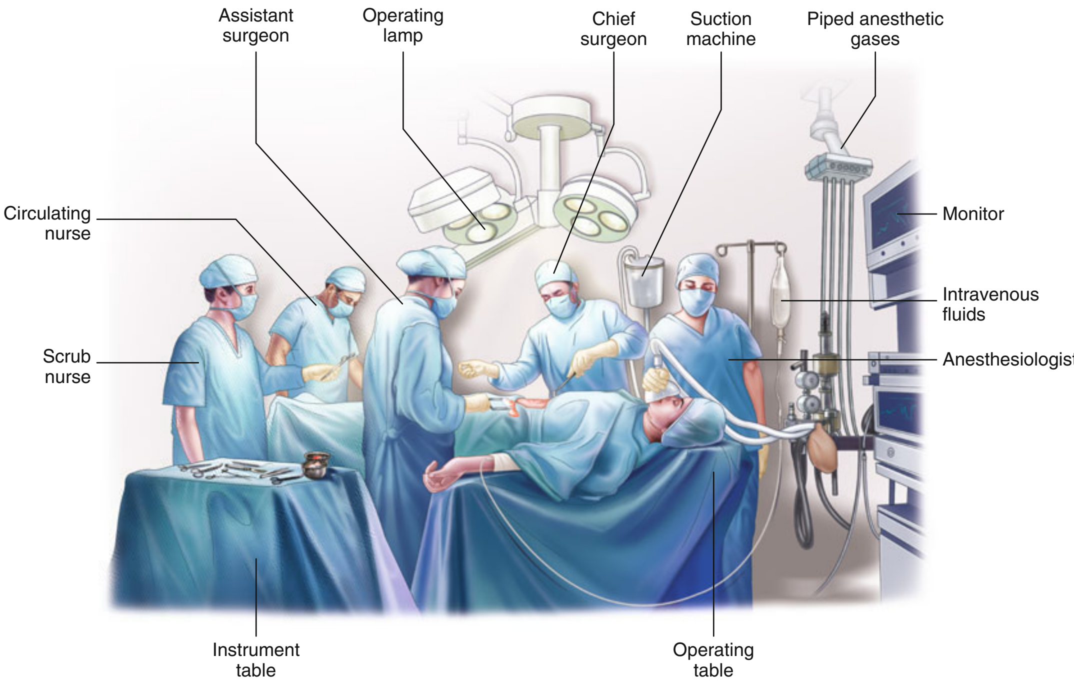

Fig. 1.3 Members of the OR team conducting a surgery

Fig. 1.4 A typical operating table

Fig. 1.5 The electrosurgical units are shown in the *top* and *middle* of the *blue cart*

Fig. 1.6 A C-arm. Notice the clear plastic drape used for sterility when the C-arm is being used. In this photo, the drape has been gathered around the top and is no longer sterile

C-Arm

The C-arm is an X-ray unit that can provide individual X-ray pictures or aid navigation using continuous fluoroscopy. The C-arm can rotate around the operating table for both anterior–posterior and lateral images and is used to guide the surgeon in the accurate placement of hardware (Fig. 1.6).

The Patient Warmer (Bair Hugger)

Patient warmers circulate warm air through a plastic blanket that is draped over the patient during surgery. These machines are often a significant source of electrical noise (60 Hz) introduced into the IOM recording.

The Microscope

The operating microscope is commonly used during intracranial and some spinal procedures. This type of microscope is large and often has two eyepieces allowing two surgeons to operate at once. The controls for the scope are located on the handgrips. There is the option of video output to a monitor allowing others in the operating room to have the same view as the surgeon (Fig. 1.7).

Anesthesia Work Area

The anesthesia work area is where you will find both the anesthesia machine and cart. The anesthesia machine is designed to deliver medical gasses and inhaled anesthetics to the patient during surgery. In addition there are several patient monitoring devices connected to display monitors. You will notice electrical outlets on the back of the anesthesia machine. These are for use by the anesthesia team only. IOM equipment should never be plugged into the back of the anesthesia machine so as to avoid a disruption in power to this critical piece of equipment (Fig. 1.8).

Fig. 1.7 A surgical microscope sterilely draped with a clear plastic drape

The anesthesia cart resembles a large tool chest (and sometimes a tool chest is actually used). The cart contains locking drawers for the storage of injectable medications (Fig. 1.9).

Aseptic and Sterile Environments

It is commonly believed that the operating room is a completely sterile environment. This isn't true. The definition of sterility is "free from infective organisms." It would be difficult to maintain the sterility of the entire room with all of the people that must enter and leave before, during, and after a case. Instead, the OR has both sterile and non-sterile components. The non-sterile components, however, are kept aseptic meaning as free of microorganisms as possible. Once an incision has been made, the patient becomes more vulnerable to infection. Therefore, all elements that are going to be in contact with the wound exposure are to be sterile. All other items are non-sterile, but aseptically cleaned.

Fig. 1.8 An IOM station set up behind the anesthesia machine

Fig. 1.9 The anesthesia work station shown at the head of the operating table

It is important to be aware of sterile and nonsterile areas of the operating room when moving about. Sterile areas are indicated by the presence of blue drapes that cover tables or Mayo stands where sterile equipment or instruments will be kept during the procedure (Fig. 1.10). Larger items that must remain sterile such as the microscope or C-arm (X-ray) will be covered with sterile clear plastic drapes. Sterilizing such large equipment itself isn't possible, so covering with a sterile drape achieves the same effect. When walking about the room, it is imperative that you keep a distance of at least 18″ from any sterile areas. It is advisable to keep sterile areas in front of you to avoid accidental contact from behind that you may not even be aware of. If any part of your body or clothing comes in contact with a sterile surface, don't panic, but do make the circulating nurse or another member of the surgical team aware of it so that they can redrape the area or re-sterilize the instruments.

Anything that will come in contact with the operative wound must be sterilized. The process of sterilization kills all microorganisms on the surface of the item and prevents the transmission of microorganisms from the item to the patient. Once the item is sterilized, personnel who are in sterile gowns and wearing sterile gloves are the only people that may handle it. Sterilization is achieved on-site by placing the items in an autoclave. The autoclave uses high temperature and pressure to kill all microorganisms on the items. Many disposables that are used in surgery are sterilized at off-site locations where they are manufactured. These items, often plastic, may undergo sterilization using a gas called ethylene oxide (EtO). This method of sterilization is used on any equipment that cannot tolerate the high heat of more traditional methods of sterilization. Sterile items are easily identified by being loosely wrapped in a blue cloth. Another indication that instruments are sterile is if they are laying in a metal tray on top of a table that is draped in blue. Prepackaged disposable items will usually be in double packaged in clear plastic with a label indicating that the contents are sterile.

In addition to sterilization of instruments that will come in contact with the operative wound, it is equally important to sterilize the area of skin where the incision is to occur. This is called skin prepping. Prepping a surgical site on a patient involves shaving the skin around the incision,

Fig. 1.10 A surgical technologist stands in the foreground opening sterile items and placing them on the sterilely draped tables as indicated by the *blue drapes*. In the background, an anesthesiologist gets ready for the patient

scrubbing the skin with a disinfectant solution such as iodine, and then outlining this newly sterile area by taping a blue sterile drape to the patient's skin. This process creates a sterile window in which the surgeon will work. All personnel that will have contact with the instruments or the operative wound must be "scrubbed in." This means that they must carefully scrub their hands, fingernails, and arms and then don a sterile gown over their scrubs as well as sterile gloves. Personnel that are scrubbed in are to be considered sterile from fingertips to elbows and waist to shoulders (Fig. 1.11). They are not considered sterile from the waist down or from behind. Once someone is scrubbed in, you should avoid contact with these areas of their body, and they will avoid contact with any surface that is non-sterile. The members of the surgical team that go through this process are the surgeon, the surgical technologist (often called the scrub tech), and any other personnel assisting the surgeon with the procedure such as a physician assistant.

It is the responsibility of all team members to help avoid the spread of infection. Hand washing is the number one defense against infection both in and out of the OR. Hands should be washed before and after contact with each patient, when

Fig. 1.11 An example of personnel "scrubbed in." Notice they are sterile in the front from the waist up and from the fingertips to the elbows

hands are visibly soiled, and when there has been any contact with surfaces suspected of containing microorganisms. The proper technique for washing hands includes wetting the hands and applying soap and then scrubbing the hands thoroughly up to the forearms for a minimum of 20 s. Hands should then be rinsed in warm water and dried with a clean towel. Hand washing for the processes of "scrubbing in" is a more methodical process that involves a long-acting antimicrobial soap, scrubbing each fingernail in detail, and always scrubbing up to the elbows. This procedure takes a minimum of 5 min.

Communication and Documentation

A team is only as good as the weakest member. Each member of the team should understand their role and seek to carry that role out to the best of their ability, leaving behind any distractions or personal issues. The goal of each team member is to ensure a safe and effective surgical procedure. Achieving this goal requires proper communication and documentation. In order for the surgeon to concentrate on the procedure at hand, he or she must trust that the patient is being properly cared for and monitored by other members of the care team.

The neuromonitoring clinician must work with both the anesthesiologist and the surgeon to successfully accomplish the mission of monitoring the patient's nervous system during surgery. Information relayed from the neuromonitoring team to the surgeon or anesthesiologist can change the course of the surgery and avoid a negative neurological outcome for the patient. Inaccurate information regarding neuromonitoring data can harm the patient either by failing to detect an emerging injury or by creating a necessary pause or stop to surgery based on a false alarm. To ensure a successful outcome, three-way communication between the surgeon, anesthesiologist, and neuromonitoring clinician is essential.

It is essential that the communication between the surgeon, anesthesiologist, and neuromonitoring clinician be well documented. The IOM clinician should have conversations with the surgeon and anesthesiologist regarding the monitoring plan prior to the patient coming back to the OR. As the neurophysiological monitoring expert, you should present an appropriate monitoring plan to the surgeon for approval. The surgeon will have the opportunity to ask questions about a particular modality or to request that changes are made to the monitoring plan. It is much more difficult to have this conversation in the OR during the busy process of preparing for surgery. This conversation should be documented in the monitoring record, especially if the surgeon's requests are outside of commonly accepted monitoring protocols. Communication with the anesthesiologist prior to surgery is also essential. You should discuss the monitoring plan with the anesthesiologist including the effects of particular anesthetic regimens on the ability to collect monitoring data. At this time, contraindications to motor evoked potentials should be discussed as well as the location of all needle electrodes. If running motor evoked potentials, ask that the anesthesiologist place a soft bite block bilaterally. Document these communications thoroughly in the monitoring record.

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2 Anatomy of Intraoperative Monitoring

Scott Francis Davis

Introduction

Structure and function are intimately related. There is an old adage that structure subserves function. This is at once a simple and yet profound statement. Look around your environment and you will prove this concept to yourself time and again. A coffee cup, by necessity, has a hole at the top and not at the bottom. Its structure subserves the function of holding coffee. The human body is no less practically created. As an IOM professional you are tasked with protecting neural structures and functions at risk during surgery. An intraoperative neurophysiologic monitoring curriculum therefore must include a foundation in anatomy.

The neuromonitoring professional doesn't require a detailed knowledge of all anatomical systems but instead benefits from a more focused approach to relevant organs and systems that are directly involved in the monitoring plan. Generally, knowledge of the nervous, skeletal, and muscular systems is the cornerstone of the monitorist's anatomy curriculum. Equally important is the ability of the monitorist to communicate with other members of the care team using accurate anatomical terminology. This chapter provides an easily readable general overview of anatomical terminology and structures important to the neuromonitoring clinician with no previous background in anatomy.

Directional Terminology

The location of anatomic structures can be described using directional terms recognizable by all healthcare professionals. The use of proper directional terminology is necessary to avoid ambiguity with regard to anatomic locations and patient positioning. The most important thing to remember is that the position of anatomical structures can only be described relative to another structure or landmark. For example, the question "Is the thumb medial or lateral?" must prompt the follow-up question "medial or lateral to what?" A correct question would be "Is the thumb medial or lateral to the pinkie?" When answering questions such as this, it is always necessary to place the patient in proper **anatomic position**. Anatomic position is defined as the patient standing erect with the feet facing forward and slightly apart (Fig. 2.1). The hands are down at the sides with the palms facing forward. If we go back to our sample question, we say that the thumb is lateral (further from midline) to the pinkie. If we rotate the patient's hand such that the palms are now facing behind, the answer to our question did not change! This is because we must always reorient the patient to the anatomic position in our mind.

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