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Preventing surgical errors: the role of the surgical technologist

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LEARNING OBJECTIVES:

- Summarize the legal issues and aspects relating to surgical errors.
- Analyze various types of surgical errors and consequences.
- Determine the best methods of practice to avoid retained foreign bodies.
- Assess the mistakes that occur as related to wrong-site surgery and the steps that should be taken to avoid its occurrence.
- Apply the principles and practice of correctly handling drugs to avoid medication errors.

Medical errors account for over one million injuries and over 100,000 deaths each year in the United States alone.[1] While it is difficult to determine the exact number of errors traced directly to the surgical setting, several reports have provided insight into errors that do occur within the operating room. For example, the estimated prevalence of retained abdominal foreign bodies is one per 1,000 to 1,500 procedures.[2] Wrong-sided surgery occurs approximately 150 times each year.[3] Surgical procedures performed on the wrong patient, medication errors, patient falls and postoperative wound infections are also commonly noted mistakes relating to surgical patient care. One adage relating to mistakes is that "complex systems fail in complex ways." The economic burden relating to medical negligence and malpractice is staggering.[4] One of the reasons cited as leading to an explosion in health care costs is the increase in jury awards for medical negligence or malpractice. Monetary awards for medical malpractice and medical negligence have increased 300% over the past decade. This article will discuss ways in which the surgical technologist can help in the prevention of surgical errors.

Surgical errors

As far back as the early 1900s, surgeons have recognized the catastrophic results associated with retained foreign bodies. A piece written by a Polish surgeon at that time documented 101 cases involving retained foreign bodies. In 38 of these cases, the foreign body was only discovered on postmortem examination. Of these 38 cases, 19 involved a retained surgical sponge. In other cases, the retained object migrated through the bowel or vaginal wall and was subsequently purged from the patient. At least three other patients were re-explored later to have foreign objects removed. In one case, a signet ring was removed from Douglas's pouch.[5] Today, surgical sponges, instruments, towels and suture needles make up the bulk of objects retained during surgical procedures. In many of these cases, counts were documented as correct at the time.

Wrong-site or wrong-sided surgery is another frequently recognized error. News networks have widely publicized stories about the wrong foot being amputated or of a biopsy being performed on the incorrect breast.[6] These errors result in a delay of appropriate treatment or in the case of biopsies, the misdiagnosis of a patient's condition. Several cases have been identified that involve surgery performed on the wrong side of a patient's brain. In a Rhode Island case, this occurred after a CT scan was placed backward on the view-box. Arthroscopy on the ipsilateral (opposite) joint is another frequent error. Ophthalmic procedures performed on the wrong eye and removal of the incorrect anatomic structure have also been noted.

Medication errors account for significant morbidity in the health care setting. In surgery, these errors typically involve the incorrect medication being used, the incorrect dosage of medication administered or an inappropriate medication or solution injected. Extreme cases have included the injection of formaldehyde (Formalin™) into the eye and hydrogen peroxide or isopropyl alcohol injected or used as internal irrigants.[7] The use of local anesthetics with epinephrine on structures with poor vascularity has also been reported.

Other errors that occur in surgery lead to patient falls, neurological injuries, misdiagnosis of a patient's condition and postoperative wound infections. Many of these mistakes can be traced directly back to the circulator and/or the surgical technologist in the scrub role (STSR).

Legal issues

The current attitude in American society is that, if an unsatisfactory outcome related to medical intervention occurs, it must be due to an error committed by health care professionals. All too frequently, patients (or their next-of-kin) elect to sue the provider(s) and/or the facility in these situations. These lawsuits are broadly grouped into two areas: negligence and malpractice. Generally speaking negligence involves the commission (or omission) of an act that a reasonable person in a similar situation would not have committed (or omitted). Malpractice is essentially deliberate conduct that violates an individual's scope of practice. In simpler terms, negligence consists of a lapse in judgment while malpractice involves an element of intent. Most litigation relating to medical

error committed by unlicensed personnel is associated with negligence.

When an individual claims that an act of negligence occurred, she or he must usually be able to prove four elements. These elements are: duty, breach of duty, injury and a relationship of the injury to the breach of duty which is also referred to as proximate cause. For example, surgical technologists have a responsibility to account for surgical sponges. This is referred to as a duty. If the surgical technologist fails to count each of the sponges as required by the facility's policies, she or he has committed a breach of duty. If a sponge is retained after the surgical procedure, the courts will recognize that an injury has occurred. This injury occurred because the surgical technologist failed to count the sponges. This is known as proximate cause.

What if the STSR and circulator did count the sponges according to the facility's policies and identified that all of them were outside of the patient before the wound was closed, yet later the patient was found to have a sponge retained? Who is responsible for this?

In this light, let's look at the four elements again. First, there must be a duty. The circulator and STSR were required to count each sponge. Second, there must be a breach of duty. As identified above, the STSR and circulator did account for the sponges, therefore there is not a breach of duty in this case. Third, there must be an injury. In this case, a sponge was left in the patient. This is considered an injury. Finally, the injury must be related to a breach of duty. This is referred to as proximate cause. As noted, there was not a breach of duty in this case because the staff counted according to policy. Does this mean the patient lacks grounds to sue for damages? Most likely the patient will prevail in this case. The courts recognize that there are situations when an individual may not be able to prove each of the four elements of negligence.

In this situation, a legal doctrine known as the doctrine of res ipsa loquitor applies. Res ipsa loquitor is a Latin term that means, "the thing speaks for itself." In this case, it is obvious that a sponge has been left in the patient and that the only way this could have occurred is if someone in surgery made a mistake. This doctrine will apply in almost every instance in which a foreign body is mistakenly left in the patient during surgery. The normal elements of a negligence claim would be followed if it is demonstrated that the circulator and/or STSR failed to count according to established policies.

Medical malpractice is another common legal issue. Although this commonly applies to licensed medical practitioners (eg, physicians, nurses) it may be alleged that a surgical technologist committed malpractice. Malpractice generally refers to gross misconduct or intentional conduct that places the patient or others at risk of injury. The surgical technologist may commit malpractice in several ways. One way is to act outside the scope of her/his practice. For example, a surgeon may allow the STSR to perform the nerve block during local anesthesia. If this task is prohibited in the state where the STSR is employed and the STSR performs the block, she or he has committed malpractice even if no injury occurs. Another situation in which malpractice is committed is if the STSR is impaired (namely under the influence of drugs or other substances) yet participates in patient care. Fortunately, this is a very rare situation. Both of these examples involve the element of intent. In the first case, the STSR intentionally performed a nerve block and, in the second case, the STSR intentionally performed patient care while impaired. As noted earlier, intent typically separates negligence from malpractice.

Retained foreign bodies

Retained foreign bodies are probably the costliest error related to surgery. In addition to the legal fees of the facility, the hospital or clinic will have to pay costs associated with subsequent surgical procedures to remove the item and to correct any damages caused by it. It is important for the surgical team to reduce the potential for this type of event.

A number of steps can be taken to prevent this tragic occurrence. Following the facility's policies is a good first step. Most facilities have developed policies that detail when counts must be performed and which items are to be counted. In some cases, however, the wording of the policy is vague. For example, a policy may state, "Items that may reasonably be left in a patient should be counted." The word "should" does not indicate a mandatory action and is considered vague. Even if the word "should" in the previous sentence is changed to "must," there is a problem with the phrase, "reasonably be left in a patient." While everyone would all agree that sponges, needles and suture boots qualify, what about certain instruments? Should this apply to all instruments? Is it important to count retractors? What about large vascular or intestinal clamps? Bone clamps? In surgery, patients range from neonates to adults. An item that is too large to be left in a neonatal patient could easily become lost in an obese adult patient.

The standard of care relating to surgical instruments is that, regardless of the facility's policies, the STSR must remain aware of what instruments are on the surgical field throughout the surgical procedure. This standard holds true even if the institution does not have a specific policy in place for counting surgical instruments. Therefore, it is beneficial for the STSR to prepare the Mayo stand in a consistent fashion for a particular procedure. For example, each general abdominal procedure is set up the same way each time. In this way, a routine is established that allows the experienced STSR to quickly note if an item is missing from the Mayo stand. When an item is noted as missing, the STSR can immediately search the surgical field instead of waiting until the end of the procedure. When counting instruments consisting of multiple parts (eg, screws) all parts must be accounted for at the beginning of the procedure as well as at the end of the case.

Consider this scenario: A facility has a policy that states that instruments should be counted if they may reasonably be retained in a patient. The procedure being performed is an appendectomy and it is not the routine at this facility for instruments to be counted on appendectomies due to the fact the incision is fairly small (6 to 8 cm). However, after exploring the appendix, it is noted there is a mass in the cecum and the procedure immediately converts to a right hemi-colectomy. At this point, it is impractical to begin an instrument count as some instruments are already on the surgical field and more instruments are being added to the back table. Stopping the surgical procedure and retrieving all of the instruments on the field, so they may be visualized by the circulator as they are counted by the STSR, is probably not an option as it will delay patient care. Many staff members who work in facilities with policies that mandate the performance of instrument counts on major abdominal cases would probably conduct an instrument count in this situation. However, the potential for error in counting the instruments at this point in a surgical procedure is great. While some would argue this is an acceptable practice, it would be considered prudent to obtain a postoperative abdominal X-ray to ensure that no instruments have been retained in the patient.

With regard to sponges or towels used to pack the surgical wound, the STSR can use a sterile marker and glove wrapper to note the size and number of sponges or the number of towels that have been packed into the wound. The STSR can then mark off each of these as they are removed from the wound. Alternately, the STSR can notify the circulator when sponges or towels are packed into the wound and again when each is removed. This refers to items used for packing the wound during the procedure, not to sponges used for routine blotting of the wound edges.

When counts are performed, it is vital that both the circulator and the STSR verify that each counted item is accounted for. Both must see the items that are counted. This applies for initial counts, each closing count, and anytime items are counted off the field (eg, sponges discarded into the kick-bucket during the surgical procedure). Using packaging materials to verify the actual quantity of items is not acceptable in the case of an incorrect count.

Sponges are to be recorded by size and by the number in the package. It is important for the STSR and the circulator to verify that the radiopaque strip is present in each sponge that is counted. Prior to counting sponges, the band securing them should be removed so each sponge can be counted individually. In a situation where the actual number of sponges in a package is not identical to the number of sponges identified on the package wrapper, the entire package should be discarded from the field. In general, radiopaque 4" x 4" sponges (Raytec™) are packaged in groups of 10 sponges and laparotomy pads are packaged in groups of five sponges.

Suture packs that contain multiple needles pose a special challenge. When the initial count is performed, the number of needles identified on the package may be recorded. When the STSR actually opens the package to use the sutures within, the number of needles in the package is verified by both the STSR and the circulator. If the number of needles verified upon opening the package does not match the number on the package, the package should be discarded from the field and subsequently deleted from the count. The rationale for not opening all suture packages during the initial count is that it is dangerous to have opened packages of suture on the field. This practice also leads to an increased likelihood of lost needles.

The actual number of all countable, disposable items used during a surgical procedure must match the number on the package when they are first counted. Any disposable item that is counted and does not match the quantity identified on the package should be discarded from the field and bagged separately. The reason for this practice is to ensure consistency of counts and to prevent confusion when performing closing counts. This is particularly important if the team performing closing counts is not the same as the team that performed the initial counts.

Items discarded from the field, such as sponges, will be counted according to the initial number counted (eg, 10 Raytec™, 5 laparotomy pads), bagged, tied and placed off to the side. Suture needles that are removed from the field during the procedure due to contamination are secured by a piece of tape in a location that can be seen by the STSR and the circulator. Instruments that are removed from the field for any reason are placed in a location that is visible to the STSR as well as the circulator. Any item that is broken during the procedure must be accounted for in its entirety.

Counts are usually not performed prior to true emergency surgery due to a lack of time to conduct them properly. In this case, X-rays should be performed prior to removing the patient from the operating table at the end of the case. In certain situations, this is not possible as the patient is quite unstable and must be transferred to the Intensive Care Unit (ICU) immediately. When this occurs, the surgeon will order films on the patient after she or he has stabilized.

As mentioned earlier, it is good practice for the STSR to consistently prepare the Mayo stand for a particular procedure. By having practiced this routine, the STSR can have a reasonably good idea if all instruments are accounted for prior to transferring an emergency patient. Similarly, sponges can be quickly counted by the STSR and at the end of the case, if the circulator has time, he or she may count the discarded sponges. In the author's experience, although an official count has not been taken, this practice has eliminated the need for an otherwise stable postoperative patient to return to the OR for removal of a retained object.

When performing counts, a consistent method should be followed regardless of the item being counted. There are two acceptable methods of performing counts. The policy

of the institution will determine which will be used. One is to count from the incision site to the Mayo stand to the back table, ring stand and ending with items in the kick-bucket or otherwise away from the sterile field. The second method reverses the process. The count begins off the field and progresses to the ring stand, back table, Mayo stand and, finally, to the incision.

At no point following initial (preoperative) counts should linen or trash be removed from the room. In the event that subsequent counts are incorrect, the linen and trash may need to be examined to find the missing item(s). No items that have been part of a count should be removed from the room until the final closing counts are completed and verified as correct. In the event that an individual instrument is needed for another surgical procedure in a different room, the item must be recorded as being removed and its new location noted.

Initial counts of sponges, needles and other small items should be performed on every case prior to the incision being made. Initial instrument counts are performed according to each institution's policies. The number of closing counts will vary based on the type of procedure performed. The general rule is that a count is performed when a hollow viscous structure is closed (eg, urinary bladder, intestine, stomach, uterus). This is followed by a count when the cavity is closed (peritoneum or internal fascia). Finally, a count is performed when the subcutaneous layers are approximated. Counts should be completed prior to the approximation of the skin edges of the incision.

If during any closing count, an item is noted as missing, the surgeon must be notified immediately by the STSR or circulator. The STSR and circulator will repeat the count and, if the item remains unaccounted for, a search for the item is conducted.

The STSR will search all sterile fields including in and under instrument pans, under basins, under the Mayo stand and in the folds of drapes. It is not uncommon to discover that a surgeon or assistant has trapped a sponge between themselves and the surgical drape. It is appropriate to ask the surgeon/assistants to step back to see if this is the case. Sponges or suture needles used during laparotomies may also have been discarded on the drapes near the head of the patient and these areas should be searched thoroughly. Items may have also fallen through a gap in the fenestration of the surgical drape where they cannot be retrieved without contaminating the sterile field. This area should also be examined if possible, although the item(s) should not be retrieved until the incision is closed and the dressing applied. Extreme caution should be exercised if the missing item is a needle or other sharp device.

The circulator will search for missing items in any of the areas considered nonsterile. In the case of a missing needle, a magnetic device may be utilized. Items that have been separated and bagged, namely sponges, will be opened, recounted and re-bagged. The floor around the surgical field will be examined. This includes the area under the operating table and the anesthesia area. An item that has fallen to the floor may have been inadvertently kicked under the operating table. Another area where missing sponges are commonly found is immediately beneath the kick-bucket stand. Items that are not located after a search may have been carelessly discarded in a trash or linen hamper. Each of these must be thoroughly examined.

While the circulator and STSR are conducting searches for the missing item, the surgeon should take the opportunity to explore the wound for the item. If after a thorough examination of the wound, the sterile fields and the nonsterile areas of the room the missing item is not located, the surgeon should be appraised so she or he may order an X-ray to ensure the item is not within the patient. At this point, it is up to the surgeon to decide whether or not to continue wound closure. The circulator and STSR will continue to search for the missing item or items. After the wound is closed and dressed and the patient is transferred to the stretcher, the STSR and circulator will carefully examine all of the surgical drapes and linen for the missing item. This should be done while the patient is still in the room.

If all efforts have been exhausted, a variance (incident) report should be completed that documents, factually, what is missing and what steps were taken to locate the item(s). The variance report is not intended to affix blame to any party and care should be taken to avoid this. A variance report is not part of the patient's medical record and the patient's chart should not identify that such a report was completed. The patient's chart should specifically identify the missing item or items and that the surgeon was properly notified. This documentation will be on the operative record or in the nurse's notes depending on institutional policy. The variance report is designed to be a quality improvement tool and is generally not subject to review in court. However, a notation in the patient's chart that a variance report was completed allows patient's attorney to subpoena this document and introduce it into the litigation process.

The surgical technologist, by maintaining an awareness of her/his surgical fields, can help to prevent the inadvertent retention of a foreign body. Adhering to facility policies regarding the counting of items and maintaining an orderly surgical field will also help prevent the loss of items which may be retained within the patient.

Wrong-site surgery

Too frequently, the news reports that the wrong extremity of a patient has been operated on. Nonsurgical personnel wonder how this could be possible. Surgical professionals know that it is the failure of processes designed to prevent such tragic occurrences. In light of numerous occasions where the wrong body part has been operated on, many hospitals have drafted policies designed to prevent such

events. Most of these policies mandate that the surgeon and/or the patient identify the correct location for surgical intervention. These policies are often referred to as, "sidedness" policies, and they create guidelines that are to be followed from the preoperative holding area up to the point the scalpel is actually passed to the surgeon prior to incision. Many of these policies describe the marking of the correct surgical site by the patient or the surgeon. In some situations, patients have actually inscribed, "not here" or "this side" prior to coming to the hospital.

Commonly, the surgeon or the patient will mark an "X" over the surgical site. Identification of the site in such a fashion can potentially lead to errors. While many would recognize that "X marks the spot," to some an "X" indicates something that is wrong. Think of the many tests taken in school and how an incorrect answer is marked. Therefore, it is becoming a standard practice that the surgeon and/or the patient place their initials over the correct site. This must be performed prior to the patient being sedated.

Another common mistake that leads to wrong-site surgery is assuming the surgical schedule is correct. It is not unheard of for miscommunication between the surgeon's office staff and the surgical scheduling staff to lead to an incorrect surgical procedure or an incorrect side to be identified on the printed schedule. It is up to the staff caring for the patient to ensure the correct surgical procedure is performed at the correct location. It is vital that this is determined prior to the patient being sedated in order to prevent a potentially catastrophic injury to the patient when they get to the operating room.

Wrong-site surgery does not occur because of one mistake. This situation is the result of a series of errors. The Joint Commission on Accreditation of Health Organizations (JCAHO) recognizes wrong-site surgery as a sentinel event. A sentinel event requires an in-depth review of the processes leading up to the injury or potential injury.

Here is one example: Following physical examination the surgeon determines a patient is a candidate for arthroscopy of the left knee. The surgeon has his office staff schedule the procedure at the local hospital. The scheduling office personnel at the hospital generates the surgical schedule identifying a right knee arthroscopy which is then posted for the OR staff to read. The patient is checked into the preoperative holding area where the surgeon, circulator, surgical assistant and anesthesia provider each interview the patient. While interviewing the patient, the surgical assistant touches the patient's left leg and asks, "Are we doing the right leg?" to which the patient agrees. The surgeon arrives in the holding area, marks an "X" on the left knee of the patient, then the patient is sedated and wheeled into the operating room. A spinal anesthetic is administered, the assistant applies a tourniquet to the right leg without uncovering the left leg (to maintain the patient's dignity) and leaves the room to scrub. The circulator proceeds to prep the right leg and the STSR and assistant properly drape the right leg. The surgeon scrubs in and proceeds to perform the arthroscopy on the right leg, which is noted as unremarkable. After the incisions are dressed, the drapes are removed, and the surgeon realizes the error. What went wrong?

In this case, the surgeon directed his office staff to schedule the patient for a left knee arthroscopy. Either the surgeon's office staff mistakenly stated to the scheduling office clerk the procedure was to be performed on the right, or the clerk mistyped "right" instead of "left" on the surgical schedule. At least five individuals (six including the preoperative holding area nurse) spoke with the patient in the preoperative area and should have asked which knee was to be operated on. The assistant, in this case, while touching the left leg asked if they were doing the right leg. In this situation, the assistant was referring to the right (anatomically speaking) as opposed to the correct leg. The surgeon did mark an "X" on the left knee, which was not uncovered prior to the application of the tourniquet. Would the assistant (had she or he noticed the mark) have assumed that the "X" meant incorrect? The circulator performed a skin prep on the right (incorrect) leg which was then draped by the STSR and the assistant. The surgeon arrived at the room and after gowning, proceeded to perform the arthroscopy on the right (incorrect) leg. How could the surgical technologist(s) in this case have prevented this error?

First, the circulator (RN or ST) should have asked the patient to state which leg was the correct leg. This may or may not have occurred in this example. Second, the surgical assistant (perhaps a surgical technologist), instead of asking if the team was doing the right leg, should have also asked the patient to state which leg was the proper leg. Third, the surgeon should always be present in the operating room prior to the positioning of a patient for a procedure. It is often difficult to identify anatomic structures when they are covered by the drapes. In this case the surgeon may also have noticed the absence of her/his mark prior to the application of the tourniquet. The circulator had a second opportunity to catch this error as she or he was prepping the leg. Finally, the STSR (RN or surgical technologist) could (should) have asked the surgeon which was the correct leg prior to passing the scalpel. Assuming that a surgical technologist was functioning in the roles of circulator, scrub and assistant in this scenario, there were at least four separate instances when this error could have been identified and prevented by a surgical technologist.

Another error related to wrong-site surgery occurs when films (X-rays, CT scans) are placed backward on the view-boxes. This error has resulted in surgery being performed on the wrong foot, the wrong hip, wrong side of the chest and the wrong cerebral hemisphere. Although an experienced surgical technologist may become quite adept at reading films, the responsibility of positioning films on the view-box should be left to the surgeon. In at least two cases of surgery being performed on the wrong cerebral hemisphere, the surgeon involved attempted to

deflect responsibility by claiming members of the surgical team, in one case the circulator, had positioned the films on the view-box.

Although the responsibility for correctly identifying the correct operative site ultimately lies with the attending surgeon, the surgical technologist has a duty to act as an advocate for the patient and can, in fact, spare the patient from a potentially disastrous outcome. Asking a simple question prior to passing the scalpel to the surgeon can give pause to the entire team and allow a few extra moments to ensure accuracy and prevent tragedy. "What is the correct side?" Five simple words will eliminate the pain and grief associated with a preventable error.

Medication errors

Two areas that require dual-confirmation between the STSR and the circulator are counts and medication administration. Medication errors have great potential to cause serious injury and death for the surgical patient. Most of these errors result from failure to correctly identify a medication or solution that is introduced to the surgical field. Documented cases include the administration of medications that the patient has a known hypersensitivity to, an incorrect medication being delivered or an inappropriate solution being used during the surgical procedure. A majority of these mistakes could be directly prevented by the STSR or circulator.

In order to prevent drug-related mistakes, it is important for the surgical technologist to have a basic understanding of the principles of pharmacology and an awareness of the types of medications and solutions used in the surgical setting. Most nurses who have completed an accredited nursing program have taken courses in pharmacology. However, most of these courses do not address medications or solutions used within the surgical arena. Accredited surgical technology programs are required to teach the basics of pharmacology, and these courses focus on areas specifically related to surgery. Specific drug classes that are discussed in surgical technology programs include anesthetic agents (inhalation and injectable), muscle relaxants, sedatives, diagnostic agents and emergency drugs (eg, cardiovascular agents, MH agents).

Prior to the introduction of any medication or solution onto the surgical field, the STSR and circulator must verify the drug name and concentration (dosage) and expiration date. Any pharmacologic substance on the surgical field must be identified in such a way that each member of the team can see what is present in a specific container. This is

How surgical instruments get left behind

Emergency surgeries and procedures with unforeseen changes are more likely to result in retained instruments and sponges than are other operations, report Boston researchers in the *New England Journal of Medicine.* Additionally, surgical items appear somewhat more likely to be left in patients with high body mass index (BMI) than in patients of normal weight.

In a search for possible risk factors for such mishaps, Gawande and colleagues reviewed records from a large Massachusetts malpractice insurer between 1985 and 2001, seeking claims and incident reports involving retained foreign bodies. For each of 54 patients they identified (with 61 retained items, approximately two thirds of which were sponges; others included clamps, retractors, and electrodes), the investigators selected about four controls who had had a similar operation, usually at the same facility, within six months' time. All surgeries were classified as emergent, urgent, or elective. The date of detection ranged from one day to 6.5 years postsurgery, with day 21 the median date of discovery.

From the literature and from interviews with surgeons, the researchers compiled a number of possible risk factors for retained objects: excessive patient blood loss, patient obesity, a fatigued surgical team, urgent surgery, necessity for more than one procedure, perioperative nursing staff changes, involvement of more than one surgical team, unexpected occurrences during surgery, and failure to account for all sponges and instruments.

Thirty-four percent of case patients underwent surgery that involved a change in procedure (vs 9% of control patients), 33% an emergency procedure (vs 7% of controls), and 88% a surgery ending with a reportedly correct item count (vs 92%; this was not considered a significant difference). BMI averaged 28.2 ± 6.3 in patients with retained objects and 26.4 ± 5.2 among controls, but this information was incomplete. None of the procedures with retained objects was a laparoscopy, an endoscopy, or a catheterization.

Malpractice claims and incident reports, the authors note, may not represent the actual incidence of any surgical mishap. Although they found instrument retention relatively rare (among the institutions studied, incidence ranged from one in 8,801 to one in 18,760 inpatient surgeries), the consequences were serious. In one case, the patient died as a result of the retained object, and 69% of patients experienced complications (eg, obstructions, visceral perforations) that necessitated repeat surgery. In cases that led to litigation, claims averaged nearly $53,000.

Gawande et al recommend active monitoring of compliance with sponge counts after every surgery (including obstetrical procedures) and instrument counts after every procedure with an open body cavity. Additionally, they approve the practice in some facilities to require radiographic screening after every open-cavity surgery; "given costs of more than $50,000 per case for malpractice-claims expenses alone, a $100 plain film could prove a cost-effective intervention," they observe.

- Gawande AA, Studdert DM, Orav EJ, et al. Risk factors for retained instruments and sponges after surgery. *N Engl J Med.* 2003;348:229-235. Reprinted by permission from Clinician Reviews (Vol 13, No. 4, pp 98,101). © 2003 Jobson Publishing, LLC.

vital if the STSR is relieved during the surgical procedure in order to ensure accurate reporting to the relief person. Ideally, identification of medications or other solutions on the sterile field is performed by labeling each container with the name of the drug, the concentration of the drug and any additives to the drug (eg, epinephrine).

It is not sufficient to simply label a container, "local," as this does not identify what the medication or solution is. Many surgical technologists think of a local as an anesthetic. Some surgeons use a saline and epinephrine solution around the incision site to control bleeding and often refer to this as local; however, this has no anesthetic properties. Likewise, the term local does not identify if a solution includes epinephrine, which is a potent vasoconstrictor.

The inclusion of epinephrine in a local anesthetic affects the amount of anesthetic that can safely be administered to a patient. Epinephrine is contraindicated for use in areas with poor circulation, namely fingers, toes, the tip of the nose, ears and the penis. An STSR who gives a surgeon a syringe containing a local anesthetic with epinephrine can be found negligent if she or he did not identify the solution as containing epinephrine. The STSR should always identify the substance that is being handed to the surgeon, especially if it is in a syringe. It is not proper for the STSR to initially hand the surgeon a syringe and say, "Local!" As the surgeon is actually administering the agent she or he has a duty to know what the drug is. The STSR should instead state the name of the medication, including additives. For example, "1% Lidocaine with epinephrine" would be an acceptable method of notifying the surgeon what is being passed to her/him. Subsequent use of the agent can be then referred to as, "Local." However, in a situation where a surgeon may use two different local anesthetics during the procedure, the name of the anesthetic should be clearly stated each time a syringe is passed to the surgeon.

It is likewise important to label each item that contains a pharmacological substance. The medicine glass that the local anesthetic is poured into should be labeled, and each syringe containing the drug should be similarly identified. In a situation where two agents are to be mixed on the field, each agent is labeled in its appropriate container and when combined, each container containing the mixture is labeled to identify the components of the mixture.

Certain medications must be administered through a certain route. For example, cocaine (4% USP) is specifically used as a topical anesthetic. Injection of cocaine may result in serious injury or death. For this reason, cocaine should never be drawn up into a syringe. Likewise, irrigating water, irrigating saline and other agents are not to be injected and should generally not be drawn into syringes. It is important for the surgical technologist to maintain an understanding of common medications and solutions in order to prevent drug-related errors.

Conclusion

The surgical technologist plays a vital role in the prevention of surgical errors. As the only member of the surgical team who is specifically trained for work in the operating room environment, it is important for the surgical technologist to have a thorough understanding of the hazards, as well as the ways to prevent these dangers from negatively affecting the care of the surgical patient. Awareness of the potential dangers allows the STSR to protect the surgeon and other members of the surgical team from physical injury as well. It is not acceptable to claim the STSR is immune from liability, because it is the nurse who holds a license. The surgical technologist code of ethics demands a strict adherence to the principles of safe patient care.

This article has identified several of the most common, yet tragic, errors that can affect our surgical patients. Also addressed are ways in which the surgical technologist can help to prevent these errors. By adhering to simple principles the STSR can reduce the risk of injury to patients, coworkers and surgeons. Following a standard of care can reduce or eliminate the liability an STSR may bear should an unanticipated outcome occur in surgery. Knowledge and vigilance are the keys to safety in the operating room.

About the author

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A robot's view of the prostate

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LEARNING OBJECTIVES:

- Recognize the relevant surgical anatomy of the prostate gland.
- Summarize the pathology of prostate gland cancer.
- Compare and contrast the unpreventable and preventable risk factors for prostate cancer.
- Apply the use of the Gleason Grading System.
- Review the surgical steps of a prostatectomy using the da Vinci Robotic System.

Media coverage, national fund raising efforts and pink ribbons have brought much-needed attention to the fight against breast cancer, raising awareness among women. The male counterpart, prostate cancer, is far more prevalent than the public realizes and doesn't get the same amount of media attention. How prevalent? Prostate cancer accounts for more than 40% of all cancers diagnosed in men, and is considered the number two killer in men second only to skin cancer. One out of every eight men will be diagnosed with prostate cancer in their lifetime. Nearly 350,000 men are diagnosed with prostate cancer each year; approximately 45,000 die annually (one every 13 minutes) of prostate cancer.[5]

Until laparoscopic technologies were available, a standard open radical prostatectomy was often performed, which had many possible complications. Laparoscopic surgery refined the technique for better patient outcomes. Robotic technology has brought additional advantages to the operating table. Laparoscopic instruments were still controlled by hand, and sensitive to the surgeon's hand tremor. Additionally, laparoscopic instruments were less flexible allowing the standard 4 degrees of freedom. Robotic technology eliminates hand tremor and allows a full 6 degrees of freedom, which is less traumatic for tissue and allows greater access for removal of cancerous tissue.

The most apparent difference between a standard open procedure and a computer-controlled laparoscopic procedure involves port incisions instead of abdominal incision.[4] From a patient's standpoint, the most noticeable outcome is the lack of abdominal pain. Patients are fully awake, alert, physically active and eating solid food within four hours of the operation.[4]

Anatomy

The prostate is a walnut-sized gland that is located below the urinary bladder. It surrounds the urethra and the vas deferens, which conducts sperm to the urethra and passes through the prostate. The glandular cells of the prostate gland add nutrients and fluid to the sperm. The anterior wall of the rectum lies only millimeters behind the prostate gland. The veins of the prostate drain toward the heart via connections that lie alongside the spine, which also lies in close proximity to the prostate gland. Lymph, the watery fluid that is in all tissues, flows away from the prostate through small channels called lymphatic channels to lymph nodes along the wall of the pelvis. Lymph nodes act to filter out bacteria and cancer cells before the fluid flows further upstream toward the veins that eventually empty into the heart.[6]

The cavernous nerves of the male reproduction system control erection and are contained within the neurovascular bundle. This bundle passes across the prostate and adheres fully to it. Any damage to the cavernous nerves could result in impotence and/or incontinence. To preserve the neurovascular bundle, dissecting around the lateral aspect of the seminal vesicles by cold cutting may eliminate damage to the neurovascular bundle. The other method used to preserve the bundle is to transect the lateral pedicle and completely exclude the neurovascular bundle.[3]

Pathology

Prostatic cancer is a malignant growth of the glandular cells of the prostate gland. Prostate cancer usually grows slowly but may grow rapidly and spread outside the prostate gland. Testosterone, which is produced in the testes, will stimulate the growth of prostate cancer. As the cancer grows, it eventually spreads outside the capsule of the gland and may spread locally to the bladder and seminal vesicles. It also spreads distally to the lymph nodes of the pelvis and to the spine.

Prostate cancer accounts for more than 40% of all cancers diagnosed in men and is the number two killer, second only to skin cancer.[5]

Unpreventable risk factors of prostate cancer

One of the biggest risk factors of prostate cancer is related to a man's age. Almost 80% of men diagnosed with prostate cancer are 65 years of age or older. Although a few men in their 20s are diagnosed with prostate cancer, 10% to 20% of men in their 30s develop the disease, but by age 50, nearly one out of every three men will have prostate cancer.[5] Family history plays a role in the prostate cancer risk factors. In the United States, the average man's risk for developing prostate cancer ranges from 10% to 15% and the average risk for dying from the disease is 3%. Conversely, if a family member had the disease, the risk of developing prostate cancer doubles.[5] Where you reside can affect your probability of dying from advanced prostate cancer. In the United States, 25% of the men who develop advanced prostate cancer will die from the dis-

ease, while in Switzerland the risk jumps to 40%. In Japan, there is a smaller risk of developing prostate cancer, but of those who develop the disease, 33% will die from it.[5] Studies show that testosterone is associated with an increased risk of prostate cancer and a high level of testosterone is thought to accelerate the growth of prostate cancer.

Preventable risk factors

Men between the ages of 50 to 70 should be screened for prostate cancer. The Digital Rectal Exam (DRE) is done annually during a physical. The physician is looking for irregularities or enlargement of the gland. The prostate specific antigen (PSA) is a blood test that measures the level of an enzyme located in the prostate. Normal levels of PSA are 0 to 4.

The environment also plays a role in prostate cancer. For example, when a man moves from one country to another, he will develop the risk of his adopted nation.[5] A diet high in saturated fat and low in fiber could increase the risk of prostate cancer. Studies link the fast growth of prostate tumors to diets of high fat.[5] Jobs in certain fields, such as water treatment, aircraft manufacturing, railway transport, utilities, farming, fishing and forestry are associated with an increased risk of prostate cancer.

Gleason Grading System

Prostate cancer is commonly evaluated using the Gleason Grading System.[5] This system is a method of describing the cancer based on how the cells look and how they are arranged from a biopsy. With this tissue sample, the pathologist will use Gleason's System to determine how fast the cancer is growing. The surgeon will take samples of the cancer tissue and assign a score of 1-5 to the two largest samples.[5,6] The sum of these two numbers is used for prognosis.

Grade 1-2	Least aggressive
Grade 3	Seldom has metastases
Grade 4-5	Commonly has metastases

Scores:

- 2-4 low-grade tumor
- 5-7 intermediate-grade tumor
- 8-10 high-grade tumor

A low-grade tumor (Gleason sum of 2-4) has normal looking cells and grows slower, whereas a high-grade tumor (sum of 8-10) has very abnormal cells and is more likely to spread outside the prostate. The treatment options vary and are based on age, tumor grade and the degree of metastasis. Several other tests will be performed to determine the spread of the disease.[6]

- **Bone Scan.** A small amount of radioisotope is injected into the bloodstream and absorbed into the bones in the areas affected by the cancer. The spine is the most common site outside of the pelvis for the cancer to metastasize.
- **CAT (computerized axial tomography) scan.** This test examines the inside of the body through the creation of computerized X-ray images. A CAT scan of the pelvis may demonstrate enlargement of the prostate gland or pelvic nodes.
- **MRI (magnetic resonance imaging) scan.** This test will create a detailed computerized image of the internal organs and bones by identifying the changes

Instrumentation and Equipment

Urology instruments

- Urology extras
- Standard laparotomy retractors
- Laparoscopic nephrectomy Set
- Dull towels clips—nonpiercing
- Warming thermos
- Male urethral sounds
- Da Vinci™ system-camera, insufflator, monitor(s)
- Allen-style stirrups
- Lenses
- Light table

Supplies

- Abdominal tray
- Skin marker
- 1000 cc pitcher
- Urinary drainage bag
- Sterile specimen cup
- 10 cc syringe
- 20 cc syringe
- Intuitive EndoWrist® Prograsp
- Intuitive large needle driver
- Intuitive Debakey forceps
- Intuitive Cautery Hook
- Intuitive Cadiere Forceps
- Intuitive Ultrasonic Shears
- Da Vinci™ Accessory Sets 1 & 2
- #400077 single use cannula seal x 2
- #400016 da Vinci™ Instrument Arm drape x 2
- #500027 da Vinci™ camera drape
- Steri drape w/long drape
- 22 Fr. 30cc Foley Catheter x 2
- Hem-o-lok® clips (green & purple)
- OneSeal Reducer Cap x 2
- Applied Medical scope warmer seal
- Hem-o-lok® applier
- Catheter plug
- Suction irrigator tubing
- Insufflator tubing
- SGT 5 & 10 mm suction irrigator tip
- SGT Verres needle
- Ligaclips®
- Endoscopic knitters
- 5 mm VersaPort® x 2
- Endopath® trocars/cannulas
- EndoPouch® specimen retrieval bag
- 10 mm Laparoscopic Babcock
- Bougie

Suture

- 2-0 Vicryl® CT1 x 4
- 2-0 Vicryl® CT2 x
- 0 Vicryl® CT1 x 4
- 4-0 Monocryl® x 2
- 2-0 Vicryl® UR6 x 2
- 2-0 Vicryl® RB1 x 5 (needed for anastomosis)
- 2-0 Vicryl® RB1 9-inch double armed

Blades

- #15, #10 and #11

Prep

- Scrub prep solution
- Betadine® soap & prep

ESU Setting

- 30/30

Medications

- Surgilube®

in the tissue molecules when subjected to a strong magnetic field.

Staging cancer

Once the cancer is graded, it will be staged to determine how far it has spread. The Jewett-Whitmore staging system uses the letters ABCD to describe the different stages.[5,6]

A The tumor is localized and is usually found during a procedure unrelated to cancer.
A1 = Cancer is small and low grade
A2 = Cancer is high grade or throughout the specimen.

B The tumor is still localized but was found by DRE, elevated PSA or other method used to detect cancer.
B1 = Cancer is limited to one side of the prostate.
B2 = Cancer is on both sides.

C The tumor has spread beyond the prostate and could be in other structures near the prostate.

D The tumor has spread far beyond the prostate to lymph nodes, bone, lungs or other organs.
D1 = Cancer is spread to only pelvic lymph nodes.
D2 = Cancer has spread to bones.

The TNM (tumor, nodes, metastasis) staging system has been adopted by the American Joint Committee on Cancer and the International Union against Cancer.[6]

Primary tumor (T)

- TX = Primary tumor cannot be assessed.
- T0 = No evidence of primary tumor.
- T1 = Clinically not apparent tumor, not palpable on rectal exam or visible by imaging.
  T1a. Tumor is incidental finding in 5% or less of tissue resected for benign enlargement of the prostate.
  T1b. Tumor incidental finding in more than 5% of resected tissue.
  T1c. Tumor identified by needle biopsy (elevated PSA).
- T2 = Tumor confined in prostate.
  T2a. Tumor involves one lobe of prostate.
  T2b. Tumor involves both lobes.
- T3 = Tumor extends through the prostatic capsule.
  T3a. Extension through capsule on one or both sides.
  T3b. Tumor invades adjacent seminal vesicle(s).
- T4 = Tumor is fixed or invades adjacent structures other than seminal vesicles such as the bladder neck, rectum, pelvic muscles or pelvic wall.

Regional lymph nodes (N)

- NX = Regional lymph nodes cannot be assessed.
- N0 = No regional lymph node metastasis.
- N1 = Metastasis present in regional lymph nodes(s).

Distant Metastasis

- MX = Distant metastasis cannot be assessed.
- M0 = No distant metastasis.
- M1 = Distant Metastasis
  M1a. Beyond regional lymph nodes.
  M1b. To bone(s).
  M1c. To other site(s).

Surgical treatment options

The standard open radical prostatectomy is indicated for patients where the cancer is confined to the gland.[4] Once the cancer has spread outside the prostate gland, the chance of totally removing the tumor is reduced. There are many disadvantages to the standard radical prostatectomy. The average length of surgery for the radical prostatectomy is three hours. Over 85% of patients required blood transfusions due to loss of blood during the procedure. 24% of the patients had positive margins. This percentage is indicative of the possibility of the cancer reoccurring because the removal of the entire cancer was not achieved. The goal of surgery would be to have this percentage as low as possible. Two percent of patients were totally incontinent due to the surgery and only one-third regained potency or returned to baseline.[6]

There are several possible complications to the radical prostate surgery.[4]

- **Excessive hemorrhage.** The prostate is surrounded with many blood vessels that easily bleed during surgery. Extensive blood loss is the reason for blood transfusion.
- **Impotence.** Because of the involvement of the nerves surrounding the prostate, the patient may not be able to have an erection.
- **Incontinence.** Damage to the neurovascular bundle during surgery can lead to injury of the nerves.
- **Bladder Neck Contracture.** This may occur due to the scar tissue when the urethral stump is sutured to the bladder.
- **Infection.** The increase chance of infection is due to the close proximity of the prostate to the rectum.
- **Tear into the rectum.** This occurs from the close proximity of the rectum to the prostate gland. If this occurs, the patient will require a colostomy during the healing process.
- **Deep vein thrombosis (DVT).** Blood clots may develop in the legs or deep pelvic veins. This can be dangerous because the clot may break loose and travel to the lung.

The first laparoscopic prostatectomy was performed in 1992.[2] The laparoscopic edge to the prostatectomy is the fact that the doctors can more easily view the prostate through a camera that will magnify the organ.[2] Ro-

botics have refined this surgery. Where laparoscopic instruments were controlled by hand, and sensitive to the surgeon's hand tremor, robotic instruments eliminate the hand tremor. Where laparoscopic instruments allowed only 4 degrees of freedom, robotic instruments allow a full 6 degrees of freedom.

The da Vinci™ surgical system is the first totally "intuitive" laparoscopic surgical robot in existence.[6] It is the first operative robot endorsed by the United States Food and Drug Administration (FDA). Da Vinci has been cleared by the FDA for several different surgical specialties, such as GYN, cardiovascular as well as urology. Over 115 surgical systems are currently in use throughout the United States, Europe and Japan. Frederic Moll, MD, Robert Younge, and John Freund, MD, built Intuitive Surgical in 1995. The system is based on foundational robotic surgery technology developed at SRI International (Stanford Research Institute).[7]

Michigan has three hospitals that currently use the da Vinci Robotic System: the University of Michigan Health Center in Ann Arbor, William Beaumont Hospital in Royal Oak and the Henry Ford Health System in Detroit, Michigan. The Henry Ford Health System, in conjunction with the Vattikuti Institute at Henry Ford has become a world leader in the treatment of prostate cancer. The American Medical Group Association (AMGA) recently awarded the Henry Ford Medical Group the top quality prize for its innovative prostate cancer program. The Prostate Cancer Options Program (PCOP) at Henry Ford is intended to enable patients to be more active in the decision making process of their treatment options concerning prostate cancer. According to Mani Menon, MD, Director of the Vattikuti Urological Institute, more than 40% of his patients that undergo a prostatectomy are requesting the da Vinci surgical system.[1]

Menon spent two years in France fine tuning his skills. Since then, Dr Bertrand Guillonneau, one of the team leaders at the Institut Montsouris in Paris, has traveled to Detroit to oversee Menon's first cases of the computer-assisted prostatectomy.[2]

Operative procedure

The da Vinci Robotic System is set up prior to the patient being brought into the room. The instrument arms are draped and then covered with a 3/4 sheet to prevent contamination. The patient is brought into the room and transferred from the stretcher to the operating table. The patient is placed in a supine position with arms tucked at the sides. The legs are placed in stirrups and spread apart to provide access to the urethra and anus area. The abdomen is shaved from the costal margins to the pubic bone. The abdomen, penis, scrotum, upper thighs and perianal region are prepped with Betadine® scrub and draped for a laparoscopic procedure with the legs draped separately. A 22 Fr Foley catheter and rectal bougie are inserted.

Three ports are needed for the da Vinci Surgical System, two assistive ports and a port in the umbilicus. Pneumoperitoneum is created with the use of a Veress needle and CO_2 is introduced to a pressure of 15mm Hg. Six puncture incisions are made with a #11 blade on a #3 knife handle. A 12 mm port is inserted in the umbilicus for placement of the binocular scope. Two eight mm ports are inserted for the da Vinci instrument arms approximately 10-12 cm from the midline just below the camera port; two 5 mm ports for assistive instrumentation and one 10 mm port for removal of the prostate are placed under direct vision with a 30 degree lens. The left instrument arm cannula is inserted between the left anterior superior iliac spine and the endoscopic port along the mid-clavicular line. The right instrument arm cannula is placed between the umbilicus and the anterior inferior iliac spine along the mid-clavicular line. Care should be taken to avoid injury to the inferior epigastric vessels. To prevent external instrument interferences there should be a minimum distance of 8 cm between the endoscopic cannula for each of the da Vinci instruments' arms. Once the ports are all placed, the surgeon will break scrub and sit at the stereoscopic console to direct and guide the robotic arms.

The patient should be placed in a 20° Trendelenburg before the da Vinci surgical cart is rolled into place. The surgical cart should be positioned so that the surgical cart column, the endoscopic arm and the endoscopic port are aligned in a straight line. The surgical cart column will be placed between the legs of the patient. The base of the surgical cart will straddle the base of the operating table. Once the cannulas are in place and the patient is in the Trendelenburg position, the colon and small bowel should be retracted and repositioned away from the pelvis using laparoscopic instruments.[4]

The extra peritoneal space is entered through a transverse peritoneal incision that is made from the left and extended to the right medial umbilical ligament. This incision is extended through an inverted U to the level of the vasa on either side. This will expose the vasa, which is then transected. The seminal vesicles are identified and freed from their attachments and vasculature. The seminal vesicles are retracted anteriorly and Denonviller's fascia is tented and incised. This will expose the plane directly behind the prostate, which will allow the tissue plane to be extended inferiorly. The instrument arms will move to the retropubic space of Retzius to continue the operation. The bladder is distended with normal saline, so its contours can be easily identified and the peritoneum is incised. The areolar tissue around the bladder is then easily dissected, causing the bladder to drop posteriorly. The bladder is then emptied. The Foley catheter remains inserted.[4]

Once all superficial and dorsal prostatic veins are coagulated; the fat over the Fascia of Zuckerkandl covering the prostate is resected or swept aside. The endopelvic fascia is incised, exposing the levator ani muscles. The pu-

boprostatic ligaments may be incised. The dorsal complex can then be ligated with a 2-0 absorbable suture passed with a curved needle from one side to the other.[4]

To identify the bladder neck, the anterior pre-vesical fat is retracted superiorly that causes an outline of the prostatovesical plane. The plane is acknowledged through sharp and blunt dissection. The urethra is identified, and the anterior wall is incised to expose the Foley catheter. The catheter balloon is then deflated and the catheter is pulled up and into the abdomen to expose the lateral and posterior bladder neck, which is incised precisely maintaining a clean detrusor margin for subsequent urethrovisical anastomosis. The Foley catheter is removed, and the posterior face of the bladder neck is exposed with a bladder mucosal incision.[4]

The surgeon will then need to expose the prostatic pedicles. The vas deferens and seminal vesicle are grasped through the space between the prostate and the posterior bladder neck and pulled up to expose the pedicle to be incised. Once the pedicles are transected, the surgeon will identify the neurovascular bundle. In order to preserve the bundle, a lateral incision is made in the visceral fascia that covers the peri-bundle fat. Cautery should not be used near the neurovascular bundle, as thermal damage to the neurovascular bundle may cause impotence or incontinence. The neurovascular bundle is transected from the base of the prostate to their entrance in the pelvic muscular floor that is posterolateral to the urethra. The dorsal vein is ligated with 2-0 absorbable suture and retracted anteriorly to expose the anterior urethral wall that is also incised. The back wall of the urethra is incised with a laparoscopic cold knife. Gentle traction is applied to the prostate, positioning it superiorly. The rectourethralis is divided.[4]

The anastomosis is completed with interrupted sutures. The anastomosis is accomplished with a 2-0 RB1 9-inch double-armed absorbable suture on a curved needle. The first two sutures are placed at the 5 and 7 o'clock positions going from the inside out of the urethra and outside in on the bladder neck. The two sutures are tied inside the urethral lumen. Four other sutures are symmetrically placed at 4 and 8, then 2 and 10 o'clock and tied outside the lumen. The final stitches are placed at 1 and 11 o'clock and tagged. The Foley catheter is inserted and the correct position is checked. The final two sutures are tied without compromising the catheter.[4]

An endo catch™ is passed through the 10 mm port. The specimen is placed in the sac and removed. The abdominal pressure is lowered to 5 mm Hg to check for bleeding. A Jackson-Pratt drain is passed to the pelvis and sutured to the skin. The remaining trocars are removed and the incisions are closed with a 4-0 Monocryl and dressed.

Conclusion

With consent of the laparoscopic procedure, the patient should understand there is a risk of converting to an open procedure. It will become necessary to convert in the event of major bleeding, rectal or ureteral injury, or problems with the urethrovesical anastomosis.[5]

Complications of the da Vinci prostatectomy are minimal compared to the standard open radical prostatectomy. Perioperative complications include a port-side hernia, hematomas, constipation or DVT.

The major advantage of the robotic laparoscopic prostatectomy is the postoperative recovery for the patient.[4] With the elimination of an abdominal incision, parenteral analgesics and/or epidural analgesia are not needed.[5] The means the patient is more alert and able to function more quickly. The patient will usually go home within 24 hours excluding any complications without any restrictions.

International studies of more than 800 patients confirm that a laparoscopic prostatectomy is as effective as the standard radical prostatectomy for treating prostate cancer.[5] The radical prostatectomy is considered one of the most successful therapies, as 85% of men will still cancer free after 10 years.[1]

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Ovarian Cystectomy and Bilateral Tubal Ligation: A Case Study/Part I

VALERIE ROCHE, CST

LEARNING OBJECTIVES:

- Interpret the information provided by the medical and surgical histories, including patient medications.
- Summarize the normal values of preoperative diagnostic studies.
- Compare and contrast amoxicillin and vancomycin according to the needs of the patient.
- Prepare the O.R. according to the procedure to be performed.
- Apply the concepts of patient care in the preoperative holding area.

Case study biographical information

This patient is a Caucasian woman, born October 15, 1960, who is divorced and lives in New York. Her religious affiliation is Catholic. She smoked two to three packs of cigarettes per week for 20 years and quit smoking in 1995. She drinks alcohol socially—approximately one drink daily and two to three drinks daily on weekends. The patient has three children, two of whom are living at home. She has a high school education and works in an office environment.

Physical condition upon admission

Medical history

The patient has mitral valve prolapse and needs prophylactic antibiotics. This is a condition in which the leaf-like part of the mitral valve drops down during contraction of the heart, allowing leakage or regurgitation of small amounts of blood into the atrium.[1] She should take antibiotics before dental and surgical procedures because of the risk that bacteria introduced during the procedure might infect the heart valve.[2]

She also takes medication for an anxiety disorder. Anxiety is a normal response to stress. However, when anxiety occurs at inappropriate times or is so intense and long-lasting that it interferes with a person's normal activities, it is considered a disorder.[2]

The patient experiences shortness of breath upon exertion and says her other asthma triggers include the weather and an allergy to cats. Asthma is a condition in which the airways are narrowed because hyper-reactivity to certain stimuli produces inflammation; the airway narrowing is reversible.[2]

The patient also states that she has an ulcer. A peptic ulcer is a well-defined round or oval sore where the lining of the stomach or duodenum has been eaten away by stomach acid and digestive juices.[2]

Surgical history

In 1966, the patient had an appendectomy, which is the surgical removal of the vermiform appendix. Appendectomy is performed for acute appendicitis that is usually caused by obstruction of the appendiceal lumen. It manifests as inflammation.[3]

In 1983, she had a cholecystectomy which is the excision of the gallbladder. Cholecystectomy is primarily performed for acute cholecystitis that commonly results from obstruction of the cystic duct by trapped gallstones.[3]

The patient has had multiple breast cyst biopsies and aspirations. Cysts are fluid-filled sacs that can be easily felt. Aspiration is the draining of the fluid with a thin needle to relieve pain caused by the cyst.[2]

The chart also indicates that she had a right knee arthroscopy. There is no date for this procedure. Arthroscopy of the knee is performed for diagnostic purposes, for removal of loose bodies that can cause the knee joint to lock in place, for shaving the patella and torn meniscus, or for meniscectomy.[3]

Allergies

The patient has several allergies. She says that if she takes codeine, she gets hallucinations. Codeine is an opiate analgesic and an antitussive that depresses pain impulse transmission.[4] She is allergic to penicillin, a broad-spectrum anti-infective which interferes with bacterial cell wall replication; it gives her hives. Ceclor® (cefaclor) is an anti-infective, second generation cephalosporin that inhibits bacterial cell wall synthesis.[4] This agent causes her to vomit and itch. Sulfimycin® (an anti-infective) is a combination product composed of 200 mg of erythromycin and 600 mg of sulfisoxazole per 5 ml. Both erythromycin and sulfisoxazole suppress bacterial protein synthesis.[4] Sulfimycin causes her skin to erupt in hives. The patient stated that pain medications cause her dizziness, hallucinations and vomiting.

Current medications

The patient takes the following medications routinely:

1) Xanax® or alprazolam (antianxiety, sedative, hypnotic) depresses the central nervous system and is used to treat anxiety.[4] Her oral dose is 1 mg daily.
2) Zantac® or ranitidine (histamine receptor antagonist) inhibits gastric acid secretion and is used to treat gastric ulcers.[4] Her oral dose is 150 mg twice a day.

3) Glucotrol® or glipizide (antidiabetic agent) causes a release of insulin that leads to a drop in blood glucose levels. It is used to stabilize adult-onset diabetes mellitus.[4] Her oral dose is 2.5 mg twice per day.
4) Ambien® or zolpidem (sedative, hypnotic) depresses the central nervous system. It is used to treat insomnia short-term.[4] The patient's oral dose is 10 mg at bedtime.
5) Claritin® or loratadine (antihistamine) provides antihistamine action without sedation. It is used to treat seasonal rhinitis.[4] The patient's oral dose is 10 mg every morning.

The patient's medications indicated treatment for diabetes mellitus and insomnia, which had been omitted from the medical history she had given.

Preoperative diagnosis and contributing findings

The history of the patient's illness included left lower quadrant pain for three months, sharp pain radiating to her hip for two months, and a history of a left ovarian cyst. The cyst was documented in the chart by three separate sonogram reports done in August, October and December of 2002. Sonograms are diagnostic tests that use sound waves to produce an image of an organ or tissue. Ultrasonic echoes are recorded as they strike tissues of different densities.[1] "Because ultrasound can distinguish subtle variations between soft, fluid-filled tissues, it is particularly useful in providing diagnostic images of the abdomen."[5]

The first medical sonograms were produced in the 1950s and in the 1960s came into general medical use. The great advantage over X-ray imaging technologies is that ultrasound does not damage tissues with ionizing radiation, but uses sound waves above the frequency of human hearing—between one and 10 million hertz (Hz).[5] It is warranted as a diagnostic tool for patients afflicted with abdominal pain, as in this case.

The preoperative diagnosis was chronic pelvic pain, left ovarian cyst, and multiparity. Based on the results of the successive sonograms it was obvious that the size of the cyst was increasing.

Preoperative diagnostic studies

Laboratory work is dated 1-28-03, and the values were posted to the patient's chart.

Differential blood count

Lymphocytes: These cells are the primary means of providing the body with immune capability. Less than 1% are present in the circulating blood; they travel back and forth between the circulating blood and the lymph nodes. They constitute 20% to 44% of total white cells in the circulating blood.[1] Normal range is 20%-40%; patient level was 24.9%.

Monocytes: White blood cells that circulate in the bloodstream for 24 hours then move into tissues and become macrophages. They are one of the first lines of defense in the inflammatory process.[1] Normal range is 0-7%; patient level was 7%.

Neutrophils: The most common white blood cell, comprising 50%-70% of the total. They are responsible for much of the body's protection against infection. When killed they release an enzyme that results in the formation of pus.[1] Normal range is 40%-65%; patient level was 63.9%.

Basophils: A type of white blood cell that is essential to the non-specific immune response to inflammation, because it releases histamine and other chemicals that act on blood vessels.[1] Normal range is 0-1%; patient level was 0.5%.

Eosinophils: A type of white blood cell that destroys parasitic organisms and plays a major role in allergic reactions. It releases chemical mediators that cause bronchoconstriction in asthma.[1] Normal range is 0-8%; patient level was 3.7%.

Hematology

These are tests of the blood and blood-forming tissues.[1] White blood cell (WBC) count is the number of leukocytes per microliter (µl) of whole blood. Leukocytes average 5,000 to 10,000 per microliter. They are primary effector cells against infection and tissue damage. They destroy organisms and act as scavengers. White blood cell counts are important in detecting infection or immune system dysfunction. The numbers and type of white blood cells are determined by microscopic examination of a thin layer of blood on a glass slide.[1] Normal range is 3,500-10,000/mm^3; patient level was 10,200/mm^3. This slight elevation in white blood cell count is probably due to stress and emotional upset.[6] The patient was very upset prior to surgery.

Red blood cell (RBC) count is the number of erythrocytes per microliter of whole blood. In women, 4.5 million per microliter is an average count. The primary function is to carry oxygen and act as a buffer for the transport of carbon dioxide in the plasma.[1] A red blood cell count provides information critical to physiological functions.[7] A decrease causes hypoxia, an oxygen deficiency.[1] Normal range is 4.5-5.3 million/mm^3; patient level was 4.85 million/mm^3.

Hemoglobin (Hb) is the iron-containing pigment of the red blood cells. A low value for hemoglobin may indicate anemia, which is a deficiency in the quantity or quality of erythrocytes.[7] Normal range is 12-16 g/dl, patient level was 14.4 g/dl.

PATIENT'S SONOGRAM RESULTS

Date	Result (dimensions of left ovarian cyst)
8/8/02	69 x 51 x 48 mm
10/21/02	69 x 54 x 47 mm
12/12/02	78 x 67 x 53 mm

Hematocrit (Hct) is the volume of erythrocytes packed by centrifugation in a given volume of blood and is expressed as the percentage of total blood volume.[1] Normal range is 35-47%; patient level was 41.9%.

Mean Corpuscular Volume (MCV) is a measurement of the average size or volume of a single red blood cell. This test helps differentiate among the anemias.[7] Normal range is 85-95 FL; patient range was 86.3 FL.

Mean Corpuscular Hemoglobin (MCH) is the hemoglobin content of the average red blood cell expressed in picograms per red blood cell. It is calculated by multiplying the number of grams of hemoglobin per 100 milliliters by ten and dividing by the red blood cell count. This test differentiates among the anemias.[7] A picogram equals one trillionth of a gram.[1] Normal range is 27-32 pg; patient level was 29.7 pg.

Mean Corpuscular Hemoglobin Concentration (MCHC) is a measure of the average percentage of hemoglobin within a single red blood cell. It is the hemoglobin concentration per unit volume of red blood cells. It differentiates among the anemias.[7] Normal range is 31-36 g/dl; patient level was 34.3 g/dl.

Platelet Count (PLT) evaluates, diagnoses and monitors bleeding and coagulation (clotting) disorders.[8] Platelets play an important role in blood coagulation, hemostasis and thrombus formation. They form a plug (clot) that covers an injury.[1] Normal range is 150,000-400,000/mm^3; patient level was 375,000/mm^3.

Red Blood Cell Distribution Width (RDW) tests variations in red blood cell size. It is used to classify and differentiate among the anemias.[4] Normal range is 11.3-13.5%, patient level was 12.0%.

Special hematology

Partial Thromboplastin Time (PTT) measures the intrinsic coagulation time and monitors anti-coagulation therapy.[7] The test screens for deficiencies in clotting factors and detects platelet variations. It is more sensitive than the prothrombin time test.[6] Normal range is 22.0-37.5 seconds; patient level was 22.1 seconds.

Prothrombin Time (PT) is the time it takes for clotting to occur after thromboplastin and calcium are added to decalcified plasma. This test is used to evaluate the effect of the administration of anticoagulant drugs.[1] Normal range is 10.3-14.0 seconds; patient level was 10.7 seconds.

International Normalized Ratio (INR) is a ratio that compares tissue thromboplastin from any source to human brain tissue thromboplastin by dividing the patient's prothrombin time by the mean prothrombin time value of the population. Normal range is 0.7-1.2; patient level was 0.78.

Comprehensive metabolism panel

These tests measure fluid and electrolyte imbalances. Correct balances greatly influence the outcome of surgical intervention.[7]

Glucose is the most important carbohydrate in body metabolism. This test is used to assess the handling of glucose by the body. When blood sugar (glucose) level rises, glucose appears in urine and is a symptom of diabetes. A low level of glucose is called hypoglycemia.[1] Normal range is 70-110 mg/dl; patient level was 169 mg/dl.

The patient takes 2.5 mg of glipizide (Glucotrol®) twice a day to stabilize adult-onset diabetes mellitus (Type II). She had not taken her medication the day of the surgery when these laboratory tests were done. When blood sugar is elevated, there is not enough insulin. Levels higher than 120 mg/dl indicates diabetes.

Blood Urea Nitrogen (BUN) measures the metabolic waste products eliminated by the kidneys. When kidney filtration function is impaired and when dehydration occurs, the BUN is elevated.[8] Normal range is 7-20 mg/dl; patient level was 9 mg/dl.

Sodium is a key regulator in water balance, and is necessary for normal functioning of muscles and nerves, and for normal metabolism.[7] Normal range is 135-147 mEq/l; patient level was 135 mEq/l.

Potassium is essential for electrochemical reactions for cellular functions.[7] It also tests kidney and adrenal gland function.[8] Normal range is 3.8-5.0 mEq/l; patient level was 4.0 mEq/l.

Chloride is essential to electrochemical reactions for acid-base regulation, and for the movement of water between fluid compartments in the body.[7] It also combines with sodium in the blood.[1] Normal range is 100-108 mEq/l; patient level was 101 mEq/l.

Carbon dioxide in a blood profile tests for acid-base imbalance from a variety of possible causes including respiratory failure, kidney disease, diabetic acidosis and diarrhea.[8] Normal range is 24.0-32.0 mEq/l; patient level was 27.0 mEq/l.

Creatinine is a normal constituent of urine.[1] It is a chemical normally found in blood that is excreted in the urine. The filtration function of the kidneys can be assessed by comparing the amount of creatinine in the blood with the amount excreted by the kidneys.[8] An increase may mean kidney failure or dehydration.[8] Normal range is 0.5-1.5 mg/dl; patient level was 0.7 mg/dl.

Calcium is essential to normal muscle physiology and is an intricate part of the blood clotting mechanism.[7] It can indicate problems with the parathyroid and thyroid glands, bone diseases and kidney malfunction.[8] Normal range is 8.5-10.5 mg/dl; patient level was 9.1 mg/dl.

Total proteins reflect metabolic and nutritional status in a wide variety of disorders, and some cancers cause an overproduction of proteins.[8] Normal range is 6.0-8.6 g/dl; patient level was 7.1 g/dl.

Albumin is a simple protein found in the blood as serum albumin that acts as a carrier to maintain blood volume and blood pressure.[1] In some forms of liver and kidney disease and in malnutrition, albumin is reduced.[8] Normal range is 3.5-5.0 g/dl; patient level was 4.1 g/dl.

Bilirubin is the orange-yellow pigment in bile derived from the hemoglobin of red blood cells that have died.[1] The test helps determine liver function.[1] Normal range is 0.2-1.0 mg/dl; patient level was 0.7 mg/dl.

Alkaline phosphatase (ALP) is used to assess liver condition.[7] It functions in the mineralization process of bone.[1] Normal range is 45-124 U/l; patient level was 50 U/l.

Serum glutamic-oxaloacetic transaminase (SGOT) is an intracellular enzyme involved in amino acid and carbohydrate metabolism. An increased level in the blood indicates necrosis or disease in the muscles, liver or brain.[1] Normal range is 7-37 U/l; patient level was 16 U/l.

Serum glutamic-pyruvic transaminase (SGPT) is an intracellular enzyme involved in amino acid and carbohydrate metabolism. An increased level of this enzyme in the blood indicates necrosis or disease in the liver, muscles or brain.[1] Normal range is 3-31 U/l; patient level was 17 U/l.

Urine—macroscopic

A routine urinalysis was performed preoperatively. Urinalysis indicates kidney and bladder infections and diseases, certain metabolic and systemic diseases, dehydration, and urinary tract bleeding.[8]

Blood

The type and cross-match test establishes the patient's blood group (A, B, AB or O) and Rh type to ensure compatibility of transfused blood between the donor and the recipient.[8] The patient's blood type is A, Rh-positive.

The antibody screening test ensures that blood is safe for transfusion. It identifies antibodies that attack cells of the patient's own body. Presence may indicate collagen vascular disease, thyroid disorders, and adrenal disorders.[8] Normal is negative; the patient was negative.

Pregnancy test

Human chorionic gonadotropin (hCG) determines whether a women is pregnant. The hormone, hCG, is released within six days after conception. Presence of hCG indicates pregnancy.[8] The patient's test was negative.

X-ray studies

Radiographic Report: (Test done prior to surgery.)

A chest X-ray is performed to evaluate the lungs and thorax for the presence of abnormalities; to evaluate the size of the heart; and to screen for lung disease.[8] It rules out unsuspected pulmonary disease that could be communicable or would contraindicate the use of inhalation anesthetics.[7]

Two views were taken: a posteroanterior (ie X-ray passes from back to front of body), and a lateral view (ie X-ray passes through patient's side).The report stated that radiographs of the chest demonstrated the heart and mediastinal structures were within normal limits. Pulmonary vascularity was normal, and the lungs were clear. Bony structures were unremarkable, and no evidence of pulmonary disease existed.

Electrocardiogram (EKG or ECG) (test done prior to surgery)

This test records, in graphic form, the heart's function by detecting the heart's electrical activity. It provides information on the rate (eg number of beats per minute) and the rhythm (eg regularity of beats) of the patient's heartbeat. Electrodes (disks) connected to a lead (wire) detect electrical impulses given off by the body.[9] The test detects heart problems or blockages in the coronary arteries, records heart rate and regularity of heartbeats, and diagnoses heart disorders or heart attacks.[8] A normal heart beat is 50-90 beats per minute. The QRS complex shows markers for potential ventricular arrhythmias and represents atrial depolarization.[10]

PATIENT REPORT
Normal EKG and normal sinus rhythm.
Ventricular rate was 82 beats per minute.
PR interval of sinus rhythm was 164 ms.
The QRS duration was 90 ms.
QT/QTC was 372/434 ms.
P-R-T axes was 39-9-45.

Preoperative medications ordered

Due to her mitral valve prolapse, the surgeon ordered amoxicillin to be administered intravenously one hour prior to surgery. Amoxicillin is a broad-spectrum anti-infective that interferes with bacterial cell wall replication, causing it to swell and burst.[4] While the patient was in the holding area prior to her surgery, the nurse noted that she was allergic to penicillin and did not administer the amoxicillin. Amoxicillin is contraindicated for patients with a hypersensitivity to penicillins.[4] Also, amoxicillin cannot be administered intravenously; it is not available in that form.[4]

This matter delayed the preparation of the patient for surgery. The surgeon ordered 1 g of Vancomycin to be given intravenously, and an additional gram was to be administered in the operating room. Vancomycin is also an anti-infective that inhibits bacterial cell wall synthesis.[4] This drug was administered for surgical prophylaxis.

Operating room check

With the assistance of the staff, the surgical technologist conducted a room review and prepared for the surgical procedure. It entailed the following: a) closing the operating room doors; b) placement of room furniture including back table, Mayo stand, and ring stand; c) operating room table positioned under the operating lights, which were checked for functionality, and lowered and positioned for the procedure; d) bags for laundry and waste positioned and made ready; e) kick buckets checked and placed; f) suction canisters for anesthesia and the operative pro-

cedure attached and checked for proper functioning; g) two intravenous poles placed at the head of the bed on either side; h) electrosurgery (ESU) equipment connected and checked for functioning; i) outside sterility indicators checked; and the following items brought onto the field--a major pack, two towel packs, a Mayo tray, a major instrument set, a hysterectomy set, a double basin pack, a gown on the ESU, a preoperative skin prep tray, circulator set-up pack, Bard Foley Tray, 2-0 Polysorb on a V-20 needle, 2-0 Plain Gut on a GS-21 needle, 0 Polysorb on a GS-21 taper needle, and one extra gown; and j) the surgeon's preference card was checked for required equipment, supplies and preferences.

Holding area

The patient arrived late from Ambulatory Admissions to the holding area, at 7:15 am, accompanied by a friend. Her vital signs upon admission were as follows: temperature was 98.5° F; pulse was 92 beats per minute; respiration was 18 breaths per minute; and blood pressure was 144/88 mm/Hg. The patient's preoperative diagnosis was chronic pelvic pain, left ovarian cyst and multiparity.

The surgical technologist reviewed the chart with the assistance of the circulating nurse. They checked for surgical consent, which was signed, as well as for the diagnosis, history and physical, and the laboratory reports. After her arrival, an anesthesiologist visited the patient and told the surgical team that the patient refused to sign the anesthesia consent form.

The nurse and surgical technologist went to her bedside. The patient was sitting in bed and wearing a hospital gown. The surgical team checked her name and identity bracelet. They conducted a preoperative interview and confirmed that the patient had no implants, plates or screws in her body, and no false teeth or hearing aids. They reviewed her allergies, and the patient confirmed each allergy and her adverse reaction. Her wristband and chart confirmed her statements.

At this point the intravenous line on her right arm was started with 1,000 ml of Ringer's lactate. The nurse waited for instructions regarding the preoperative antibiotic.

The patient stated that she had not had anything to eat or drink since 8 pm the previous night. She had removed her jewelry before her arrival, and did not need to void. She was, however, clutching a rosary and a piece of paper on which was a written prayer, and insisted that she be allowed to take these items with her into the operating room. She was extremely anxious, stating she would refuse to sign the consent for general anesthesia. She became quite agitated about this issue.

Another anesthesiologist arrived and explained several times that the consent for general anesthesia was for her protection in the event of an emergency during the procedure. The nurse and surgical technologist also spoke with her. Eventually she relented and signed the consent voluntarily.

The patient named and understood the two surgical procedures (ie ovarian cystectomy and bilateral tubal ligation). The order for Vancomycin was issued and signed, and the drug was administered. They bagged her rosary and prayer and let her hold it. They put a cap on her head, assisted her into the wheelchair and headed for the operating room.

About the author

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Ovarian Cystectomy and Bilateral Tubal Ligation: A Case Study/Part II

VALERIE ROCHE, CST

LEARNING OBJECTIVES:

- Indicate the preoperative procedures that are accomplished in the O.R., including patient positioning, anesthesia administration and role of O.R. staff person in assisting the anesthesia provider, patient skin prep and draping.
- Compare and contrast the two procedures that will be performed.
- Summarize the steps of the operative procedure.
- Analyze the pathology report.
- Determine the postoperative course of the patient and prognosis.

General biographical information

This patient is a Caucasian woman, born October 15, 1960, who is divorced and lives in New York. Her religious affiliation is Catholic. She smoked two to three packs of cigarettes per week for 20 years and quit smoking in 1995. She drinks alcohol socially—approximately one drink daily and two to three drinks daily on weekends. The patient has three children, two of whom are living at home. She has a high school education and works in an office environment.

Operative procedure

Positioning

The patient was transported from the holding area to the operating room via the wheelchair by the surgical technologist and the circulating nurse. She was assisted onto the locked operating table from the locked wheelchair and was placed in the supine position. She was covered with a blanket but complained consistently that she was hot. When the anesthesia provider was ready, the patient was assisted to a sitting position with her back bent forward to receive the epidural and spinal anesthesia. (This process is discussed in the following section.)

She was returned to the supine position on the order from the anesthesia provider. A foam donut was provided to support her head. Both of her arms were extended on bilateral arm boards with padding and a towel underneath. She refused to have her arms strapped onto the arm boards. A pulse oximeter was attached to her right index finger, and a grounding pad for the electrosurgical unit (ESU) was placed on her upper left thigh with the setting at 30/30. The placement site for the grounding pad was dry and the skin intact. A blood pressure cuff was placed on her upper right arm, and three electrocardiogram leads were affixed to her body. Two leads were placed bilaterally on the upper anterior chest and on the left lateral chest wall.

A safety strap was secured across the patient's thighs, approximately two inches above her knees. (She did not protest this strap because she could not feel it.) Venodyne pressure cuffs, sequential pneumatic pressure sleeves, were placed around her lower legs between her ankles and knees, and set at 40 mmHg.

The surgical technologist was at her side during the positioning process. A #16 French Foley catheter with a 5 cc balloon, 10 ml of sterile water and a urinary drainage system was inserted into the urethra while the patient was in a frog leg position.

Anesthesia

The patient adamantly demanded that her pain be controlled without loss of consciousness. She received regional anesthesia, utilizing a subarachnoid block (spinal). During the spinal, two drugs were administered, Bupivacaine hydrochloride (0.75%) and Fentanyl. Bupivacaine is an amino amide local anesthetic that provides good relaxation and is long acting. Fentanyl is an intravenous opioid anesthetic agent, a potent narcotic analgesic and a respiratory depressant.[7] Morphine was also administered. It is an opiate analgesic that depresses pain impulse transmission at the spinal cord level by interacting with opiate receptors.[4]

A member of the staff braced the patient and helped maintain her in the desired position, sitting laterally on the operating table with her back curled forward and her feet resting on a stool. The circulating nurse provided emotional support by constantly reassuring her. Her chin was lowered, and her spine was flexed. The equipment included a fenestrated drape, anesthetic agents, dextrose (to make the drug heavier than the cerebrospinal fluid), antiseptic solution, needles and syringes.

The lower lumbar area was prepped (cleansed) and draped with the fenestrated sheet. Prior to placement of the spinal needle, a small amount of local anesthetic (1% Lidocaine plain) was placed into the subcutaneous tissues along the intended needle path to maximize patient comfort and cooperation. Access to the subarachnoid space was achieved by the insertion of a fine-gauge, 3-inch spinal needle through the tissues of the l3-l4 disk spaces of the vertebral column. Correct needle placement was confirmed by the presence of cerebrospinal fluid in the needle hub when the needle stylet was removed. The syringe containing the anesthetic drugs was connected to the spinal needle, making sure that air was not allowed to enter the system. The agent was slowly injected and the needle was

removed.[3] The spread of anesthetic and duration of action are influenced by the concentration and volume of the agent injected and the rate of injection.[7]

After the injection, the anesthesia provider tested the level of anesthesia by touching the patient in various places on her lower limbs. When he was satisfied that the anesthetics were effective, the patient was returned to the supine position. She was asked to relax, and the team turned her body and lifted her legs onto the operating table.

Prepping and draping

To prevent bacteria on the skin surfaces from entering the surgical wound, the skin area at and around the proposed incision site must be cleaned and disinfected. The object is to remove microbes from the skin in the shortest time and prevent rapid regrowth of microbes on the skin.[11] When preparing the patient's skin for surgery, the cleanest area is done first.[11]

An antimicrobial agent was applied using sponges, and sterile gloves were worn. Lather was removed with a dry, sterile towel. In this case, the patient's skin was prepped after the spinal anesthesia had been administered by the anesthesia provider. The circulating nurse inserted a Bard Foley catheter. A topical, antimicrobial paint was carefully applied by the surgeon using a Betadine® paint solution on 4x4 RAY-TEC sponges folded into paint sponges and clamped onto a sponge stick. The prep began approximately 3 cm below the umbilicus to 4 cm above the symphysis pubis (ie the incision line) and continued outward in rectangular-shaped strokes to an area that encompassed the nipple line to midthigh, and bedside to bedside. The pelvic area was done last.

The sterile drapes were placed on the patient by the surgeon and the surgical technologist. A sterile sheet was placed below the incision site down toward the legs and covered the patient and the table. Another sterile sheet was placed on the patient above the incision site toward the head and was attached with the assistance of the anesthesia provider to the intravenous poles at either side of the bed. Four sterile towels were placed outlining the incision site, and secured with four towel clips. A fenestrated laparotomy sheet was placed over the other drapes with the fenestration placed to give adequate exposure to the incision site.

Overview of the procedures

This case was booked as an exploratory laparotomy, ovarian cystectomy and bilateral tubal ligation, with a possible oophorectomy and possible total abdominal hysterectomy bilateral salpingo-oophorectomy. If an ovarian mass is larger than 6 cm or it persists without diminution in size for longer that three months, exploration should be done.[12] Instrumentation for all procedures is shown in Table 1.

Exploratory laparotomy

An opening made through the abdominal wall into the peritoneal cavity is called a laparotomy.[11] In this case, the exploration is a visual exam of internal organs for diagnosis, which was performed in addition to the two other planned procedures. Skin and subcutaneous tissue is incised and blood vessels are occluded. Fascia is then incised, the underlying muscles are retracted or transected, and the peritoneum is opened. The abdomen is then explored.[13]

TABLE 1 INSTRUMENTS

Description	Quantity
Hospital Major Tray	
Straight point	2
Kelly	16
Allis	6
Curved points	12
Kocher	6
Babcock	4
Mixter	4
Peanut	4
Sponge sticks	2
Short needle holder	4
Medium needle holder	2
Long needle holder	2
Towel Clip	4
#3 Knife handle	2
#7 knife handle	1

Description	Quantity
Forceps	
Regular smooth	2
Medium smooth	2
Hayes Martin	2
Short tooth	2
Medium tooth	2
Long tooth	2
Adson tooth	2
Ring	1
Scissors	
Straight Mayo	1
Curved Mayo	1
Long Metzenbaum	1
Poole suction	2
Retractors	
Army/Navy	2
Vein	2
Wide Deaver	2
Narrow Deaver	2
Harrington	2
Malleable	2

Description	Quantity
Hospital Hysterectomy Tray	
Kelly long	4
Kocher long curved	4
Kocher long straight	4
Allis long	4
Phaneuf curved	4
Heaney	2
Babcock long	4
Scissors	
Mayo curved long	1
Mayo straight long	1
Nelson	1
Tenaculum short	2
Tenaculum long	1
Uterine elevator	1
Forceps tooth long	1
Sullivan O'Connor Retractor	1
Retractor blades	3
Retractor screws	2
Needle holder long	1

Oophorocystectomy

This is the removal of an ovarian cyst. The cyst is usually enucleated if the ovarian tumor is recognized as benign, (in this case, intraoperatively, by a confirmed pathology report), and only the visibly diseased portions of the adnexa are removed.[11]

Benign ovarian tumors may be solid or cystic. In the 30- to 50-year age group, 80% of ovarian growths are benign. Serous and mucinous cystadenomas account for 19% of benign ovarian growths (excluding follicular and corpus luteum cysts). The most frequent symptoms of benign ovarian growths are slow abdominal enlargement, pain and tenderness from torsion of the pedicle, and interference with the blood supply. Most commonly, these growths are asymptomatic and discovered on a routine pelvic exam. The treatment of benign ovarian growths is primarily surgical removal with conservation of all possible normal ovarian tissue.[12]

After the peritoneal cavity is entered, the intestines are protected by laparotomy pads. Benign ovarian cysts are treated by local incision with preservation of the ovary. A frozen section confirmed the benign nature of the cyst; therefore, removal of only the cyst was justified and normal tissue preserved.[7] In this case, the patient had chronic pelvic pain and was diagnosed with a benign serous cyst that was removed, preserving her ovary.

Bilateral tubal ligation (salpingectomy)

Tubal ligation is considered a permanent method of reproductive sterilization because reversal cannot be guaranteed. The surgical technique involves removing a portion of the middle part of the fallopian tube on each side for pathologic confirmation and ligation of both the distal and proximal ends to prevent the cut ends from growing together. Tubal ligation by open abdominal approach was done in this case in conjunction with another procedure, an oophorocystectomy. Each tube was tied with suture material and a section was removed. This is called the Pomeroy technique of ligation. It is reliable, provides a surgical specimen of each tube, and causes minimal tubal destruction.[7]

Detailed description of the operative procedure

A midline incision was made with a #3 knife handle and a #10 blade. Hemostats were used to control bleeding vessels. Clamped vessels were electrocoagulated with the ESU. The wound edges were retracted. The fascia was incised superiorly and inferiorly with Mayo scissors and the ESU. With the ESU, the external oblique muscle was split the length of the incision. Bleeding vessels were controlled with hemostats. The external oblique muscle was retracted, and the internal oblique muscle and transverse muscles were split, parallel to the fibers, up to the rectus sheath with Metzenbaum scissors. These muscles were then retracted. The peritoneum was identified and entered, incised longitudinally with Metzenbaum scissors, keeping the bladder and the bowel under direct visualization at all times. Laparotomy pads and suction were used as needed. The peritoneum was retracted for the exploration with large Richardson retractors.

Exploration of the abdomen revealed a left ovarian cyst approximately 7-8 cm in the longest diameter. The uterus and right adnexa were within normal limits. Exploration revealed normal liver, spleen, stomach, bowel and diaphragm.[11]

The left ovarian cyst was elevated out of the operative field and was removed using two Kelly clamps below the left ovarian cyst. The pedicle was sutured with #0 DEXON sutures and free tied with a #0 DEXON free tie.

Attention was turned to the fallopian tubes, which were identified from the cornual region to the fimbria. The right tube was grasped with an Allis clamp in the midportion. The loop was grabbed with a #2-0 plain free tie which was doubly tied. The portion of the right tube above the tie was removed with Metzenbaum scissors. The endosalpinx was coagulated and the portion of the tube was sent to pathology. A similar procedure was done to the left tube.

Careful inspection of both adnexal regions showed no sign of bleeding. After copious irrigation with 0.9% sodium chloride solution, inspection showed no signs of bleeding. The results of the frozen section came back, indicating that the finding was serous benign ovarian cyst.

Two Kellys were used to reapproximate the peritoneal edges and the internal oblique muscles. Fascia and peritoneum were reapproximated and closed with a #0 MAXON tapered needle and a running suture. Muscle tissue was reapproximated. The external oblique fascia was closed with interrupted sutures. Retraction was done with Richardson retractors as the various layers were closed. The subcutaneous tissue was evaluated for any bleeding. Skin was reapproximated with staples (35W), and the incision was covered with Adaptic® and 4x4 dressing sponges. (Table 2)

The patient, who was awake during the procedure, complained constantly about being hot and thirsty. The surgical technologist gave her ice chips to alleviate her discomfort.

Pathology report

Specimen #1: left ovarian cyst

The specimen was received fresh for intraoperative consultation. A frozen section was ordered intraoperatively.

TABLE 2 PATIENT'S CHART

Procedure Start Time	8:20 am
Procedure End Time	9:35 am
Surgery Start Time	8:40 am
Surgery End Time	9:25 am
Estimated Blood Loss	15 ml
Postoperative Urine	400 ml, clear, yellow

TABLE 3 POSTOPERATIVE DIAGNOSTIC STUDIES

Test	Postoperative	Preoperative	Normal range	Notes
WBC	12,600/mm^3	10,200/mm^3	3,500-10,000/mm^3	Elevation may be due to patient's psychological state/ stress from surgery, or antibiotic influence.[6]
RBC	4.6 million/mm^3	4.85 million/mm^3	4.5-5.3 million/mm^3	
Hb	10.5 g/dl	14.4 g/dl	12-16g/dl	Drop may be due to blood loss during surgery (15 ml) and possible antibiotic influence. Receiving intravenous fluid can cause hemodilution.[6]
Hct	32.8%	41.9%	35-47%	Drop may be due to blood loss during surgery and antibiotic influence.[6]
MCV	71.8 FL	86.3 FL	85-95 FL	Drop may be due to blood loss during surgery.[6]
MCH	23 pg	29.7 pg	27-32 pg	Drop may be due to blood loss during surgery.[6]
MCHC	32.0 g/dl	34.3 g/dl	31-36 g/dl	Drop may be due to blood loss during surgery.[6]
RDW	28%	12%	11.3%-13.5%	Elevation may be due to increased changes in red blood cells due to blood loss during surgery.
PLT	416,000/mm^3	375,000/mm^3	150,000-400,000/ mm^3	Elevation may be due to the trauma of surgery.[6]
Calcium	8.3 mg/dl	9.1 mg/dl	8.5-10.5 mg/dl	Drop may signal malabsorption of calcium from the gastrointestinal track due to a peptic ulcer. Antibiotic influence may also be a factor.
Glucose	128 mg/dl	169 mg/dl	70-110 mg/dl	Patient is being treated for diabetes mellitus. Postoperative levels are higher than normal, but lower than preoperative levels. Anesthetic drugs can also raise glucose levels.[6]
BUN	5 mg/dl	9 mg/dl	7-20 mg/dl	Drop could be due to intravenous fluids during surgery, or lack of food.[6]
Creatinine	.8 mg/dl	.7 mg/dl	.5-1.5 mg/dl	
Sodium	136 mEq/l	135 mEq/l	135-147 mEq/l	
Potassium	4.0 mEq/l	4.0 mEq/l	3.8-5.0 mEq/l	
Chloride	102 mEq/l	101 mEq/l	100-108 mEq/l	
Carbon Dioxide	30 mEq/l	27 mEq/l	24-32 mEq/l	

This is a rapid test which may be utilized while the patient is still anesthetized. The surgeon's subsequent action is influenced by the results received.[1] There was reasonable assurance that the cyst was benign, and the surgeon removed only the cyst and preserved the normal ovarian tissue.

The specimen consisted of a cystic mass, measuring 8.1 x 5.5 x 3.5 cm and weighing 116 g. The outer surface was smooth, a pink-tan color, and somewhat transparent. Attached to the specimen was a portion of pink-tan tubular soft tissue consistent with a segment of fallopian tube, measuring 3.1 x 0.6 x 0.4 cm. When the specimen was opened, it contained serous fluid with a pale-tan, smooth inner lining. No abnormal areas were identified. The representative section was labeled "benign serous," and was identified as a serous cystadenofibroma (a cyst filled with cuboidal epithelial cells). A fibroma is a fibrous, encapsulated connective tissue tumor, irregular in shape, that grows slowly and has a firm consistency.[1] The most significant finding was that it was benign.

Specimen #2: right segment of fallopian tube

This specimen was received in saline solution and consisted of a segment of tubular structure measuring 0.7 cm in length and 0.6 cm in diameter. The serosal surface was pink-white in color and had a smooth texture. Sectioning revealed a pinpoint lumen.

Specimen #3: left segment of fallopian tube

This specimen was received in saline solution and consisted of a segment of a cylindrical structure measuring 0.6 cm in length and 0.6 cm in diameter. The serosal surface was a pink-tan color and had a smooth texture.

The diagnoses for specimens #2 and #3 were portions of fallopian tubes: cylindrical, solid, fibromuscular tissue; cross and long sections.

Postoperative diagnostic studies

Laboratory tests shown in Table 3 were performed postoperatively on January 29, 2003. For comparison, the patient's preoperative levels for each test are repeated.

Medications ordered

Postoperative orders included sips of water, an intravenous line of Ringer's lactate of 125 ml per hour, and the following medications: a) Zofran® (an antiemetic): 4 mg intravenously every six hours as needed;[4] and b) Motrin® (ibuprofen): This is an analgesic, anti-inflammatory and antipyretic. Postoperative orders were 400 mg, taken orally as needed every six hours.[4]

Postoperative visits with the patient

Postoperative recovery unit

The patient was rolled onto a stretcher in supine position with a Davis roller and was transported to the recovery area accompanied by the anesthesia provider, the circulating nurse and surgical technologist. The anesthesia provider gave a detailed status report to the recovery room nurse regarding the anesthesia administered, the patient's allergies and the procedure. The anesthesia provider attached a pulse oximeter to the patient's left index finger, a blood pressure cuff to the right upper arm, and three electrocardiogram leads to the upper chest wall and the lateral wall (Table 4). The Foley catheter remained in place as well as the Venodyne stockings. The patient's intravenous line was still intact, and the surgical technologist did not inspect the dressing, although it appeared dry.

The patient complained that she was nauseous. She agreed to take medication after three attempts by the nurse to convince her, and she was given 4 mg of Zofran® (ondansetron) intravenously. This agent is an antiemetic that prevents nausea and vomiting by blocking seratonin.[4] Within 10 minutes, the patient had fallen asleep.

First postoperative visit

The surgical technologist's initial visit to the patient to the floor of the hospital gynecology unit (10 am on January 29, 2003) was canceled by the supervising floor nurse, because the patient was too sick. The surgical technologist returned at 11:30 the same morning, (26 hours postoperatively) and saw the patient. The patient was in the supine position in bed with the back of the bed raised. She was awake.

She stated that she had not voided. According to the floor nurse, her Foley catheter was scheduled to be removed later that day. The urine in the drainage bag was yellow and clear. The patient said that she did not feel well. She had been vomiting throughout the night (until 10 am that morning), but had subsequently kept down her breakfast and water.

The patient expressed anger at her anesthesia provider. She was walking and stated that she had no pain or discomfort from the incision, which appeared to be dry and intact. The sequential stockings were not on her legs. Her only complaint was that the antinausea medication had not worked. The patient asked the floor nurse to assist her in taking a bath, and the surgical technologist left.

TABLE 4 INITIAL VITAL SIGNS

Oxygen Saturation Rate	98% (a nasal cannula was not used)
Heart Rate	95 beats per minute
Blood Pressure	150/89 mm/Hg
Respiration	18 breaths per minute
Temperature	96.5 F

Second postoperative visit

The surgical technologist arrived on the floor at 11 am, and the patient was sitting on the bed, dressed to go home. The floor nurse was reviewing her doctor's postoperative orders and home care. She seemed in much better spirits. She stated that she felt no pain or discomfort. She had voided, had a bowel movement, and was eating normally. Her color was improved. The surgical technologist wished her well.

Discharge instructions

Orders included a return to a regular diet, a check-up with the surgeon after one week, no strenuous activity, and no coitus for six weeks. Postoperatively, the patient did remarkably well.

Prognosis

The patient is expected to recover fully from her surgical procedure. There were no complications from the surgery, and she is fundamentally in good physical condition and health.

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Intracranial Stereotactic Navigation: Cost Analysis and Patient Outcomes Reviewed

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LEARNING OBJECTIVES:

- Compare and contrast the various uses of the MRI in the treatment of brain tumors.
- Analyze the cost effectiveness of MRI.
- Assess the positive and negative values of MRI.
- Recall the defined medical terms.
- Summarize the use of the frameless stereotactic navigation in combination with the use of intraoperative MRI.

Introduction

Intracranial neoplasms or brain tumors comprise only a small percentage of the growths that are seen in patients. Surgery to diagnose and treat brain tumors can be quite involved for both the patient as well as the personnel involved in the operation itself. The traditional means of operating on intracranial neoplasms was that of a craniotomy, which involves removing and replacing a section of the skull. This surgery, although at most times routine, has become less and less frequent. In this day of micro technology and computers, surgeons are looking to "build a better mouse-trap." Also, in an environment of increased health care costs, lowered reimbursement for the surgeons, and hospitals that are cracking down on lengthy surgical procedures, stereotactic navigational surgery has become an accepted modality in neurosurgical practice.

Minimally invasive surgery has become the standard of care for the surgical patient. Whether it is a gallbladder that is being removed or the resection of a colloid cyst of the third ventricle in the brain, the goals are the same: to provide the patient with a treatment of the disease or the slowing of its symptoms, minimize the surgical risk involved, preserve the normal anatomy, and most importantly, promote a rapid recovery so the patient can return to work and family. The use of stereotactic navigation in the realm of neurosurgery provides the patient and the surgeon a means of achieving these goals.

Several years ago, a patient being treated with craniotomy for a tumor was informed about the risks involved. These risks sometimes outweighed the benefit of having the surgery. With the recent advances in stereotactic navigation, the neurosurgeon is able to operate on the more refined areas of the brain with greater precision, while reducing morbidity.

Review of literature

Kelly stated that, "The stereotactic surgery of the future may employ all or a combination of the following technologies: frameless stereotactic surgery, robotic technology, microrobotic dexterity enhancement, and telepresence robotics."[7] This statement has never been more true. Although surgery is several years away from robots taking the place of skilled surgeons operating on fragile areas of the brain, there are other devices that are in the surgeon's arsenal to enhance the patient's outcome from a potentially life-threatening surgery.

Bhardwaj and Bernstein surveyed the practicality of performing a brain biopsy using a framed-based stereotaxis system from a financial and patient satisfaction standpoint.[1] For a period of five years, from August 1996 to August 2001, the study was conducted on a total of 76 patients. The group was broken down into gender, with 41 female and 35 male patients. The mean age of the group was 56.9 years of age, with ages ranging from 18 to 86 years.[1] A stereotactic ring was secured to the patient's head using local anesthetic. The patient underwent a nonionic contrast, computerized tomographic scan of the head and frame. These images were then used to guide the biopsy needle into the area of concern. The biopsy procedure itself was carried out in the operating room using standard sterile technique. The skull was penetrated using a standard 7 mm burr hole. A biopsy needle was then introduced into the brain and a section of tissue was removed. One tissue sample was routinely obtained. At the completion of the procedure, the patients were transferred to the recovery room, where they were closely monitored by the nursing staff. After a total of four hours of observation, the surgeon assessed and approved the patient for discharge.[1]

The most commonly diagnosed lesions were that of glioblastoma multiforme (35 patients). Other forms of brain cancer and infections comprised the rest of the pathological findings (41 patients). Bhardwaj and Bernstein also reported the most common site of surgery was that of the frontal lobe.[1] The success rate of the study was 97.4%. Out of the 76 patients operated on, two patients were not discharged from the hospital because the biopsy procedure itself could not be performed, and the patients underwent extended observation and further investigation.[1]

The authors reported two complications among the study group. One patient with a deep-seated glioma had degeneration of neurological status. Another patient developed an intraventricular hemorrhage as a complication of the procedure. Both of these patients were still discharged on the day of surgery.[1]

The cost analysis was carried out using a software program. The original figures are in Canadian dollars, with US equivalents listed in parentheses.[10] At the institution where the surgeries were performed, the cost of a one-night stay in the intensive care unit is $2,400 CAD ($1,757 USD). The cost of a night's stay in a neurosurgical step-down unit is $1,800 CAD ($1,318 USD). Finally, the cost of a home-care nurse visit is roughly $60 CAD ($44 USD). The current trend for a brain biopsy is for a patient to spend one night in the neurosurgical intensive care unit or step-down bed before being discharged. Therefore, the average savings of a strictly outpatient approach to stereotactic brain biopsies range from $1,740 CAD ($1,274 USD) to $2,340 CAD ($1,714 USD).[1]

DEFINITIONS OF TERMS

Brain shift. A slight shift in brain position caused by gravity acting on the brain after the skull is opened. The forces of gravity act upon the brain itself by pulling it toward the ground. This, combined with the aspiration of cerebrospinal fluid, allows the brain to relax.

Collimation: The radiological method shaping and confining the X-ray beam to a given area based on the patient's tumor.

Ferromagnetic: Relating to or demonstrating the magnetic attraction of iron containing materials.

Fiducials: Special stickers impregnated with barium sulfate that create a radiopaque markers on the patient's skull. These stickers take the place of a frame being bolted to the patient's head.

Glioblastoma multiforme: A type of brain tumor that forms from glial (supportive) tissue of the brain. It grows very quickly and has cells that look very different from normal cells.

Intracranial: Pertaining to inside the cranial vault.

Pallidotomy: A surgical procedure in which a part of the brain, called the globus pallidus, is lesioned in order to improve symptoms of tremor, rigidity, and bradykinesia. A pallidotomy is a surgical procedure where a needle is guided into the area of the brain that controls fine motor movement and a lesion is literally burned into the patient's brain, thus stopping the transmission of damaged signals to the extremities.

Radiosurgery: A technique for treating inoperable brain cancers; a CT scan is used to locate the tumor, which is then bombarded with precise, high doses of radiation.

Sella turcica: The bony structure that houses the pituitary gland.

Stereotactic: A radiation therapy technique involving a rigid head frame that is attached to the skull; high-dose radiation is administered through openings in the head frame to the tumor while decreasing the amount of radiation given to normal brain tissue.

Transsphenoidal: Through the sphenoid bone.

Bohinski et al reported on the use of magnetic resonance imaging (MRI) to aid in the resection of glial cell brain tumors. The system utilized in the study was that of a Hitachi vertical field open MRI scanner. The scanner was located adjacent to the operating suite.[2] Although the cost of the scanner was not disclosed in the report, it can be said with confidence that a scanner of this capacity costs in the area of $1 to $1.5 million, with the building of a MRI-safe operating room and equipment adding $3 to $4 million to the price tag.

Bohinski's study stated that, after removal of all visible tumor by the neurosurgeon, the dura mater, skull, and scalp were loosely approximated and covered with a sterile drape. The patient was then transferred to the MRI scanner where the head was fixed in the scanner.[2] Contrast enhanced images were then obtained. Although total scan time of the patient varied, due to various imaging needs, the mean scanning time reported was that of 16 minutes.[2] If the area of resection was satisfactory to the neurosurgeon's expectations, the skull was closed primarily in a standard fashion in the MRI suite. However, if more resection was required, the patient could then be brought back into the operating room.[2]

The accuracy of the MRI scans was quite impressive. Out of a total of 40 patients, 15% of the scans obtained were indistinct and unusable.[2] Materials in the room and on the patients themselves had interfered with the quality of the magnetic images. These scan-altering objects were removed, and the patient was rescanned. In the study group, 53% of the patients required additional resection of the mass, and 12.5% of the patients in the group had worsening of neurological symptoms, with one patient who expired due to an unrelated air embolus in the pulmonary artery.[2]

Even though the neurosurgical community has received great criticism for the use of the intraoperative MRI, Bohinski's group argues the importance of it. They state that, "one of the goals of our MROR (Magnetic Resonance Operating Room) design was to incorporate sufficient flexibility so that other practitioners (those referring patients for diagnostic imaging or those interested in developing peripheral interventions for other organ systems) could use the MRI center routinely."[2]

Although the primary use of the MRI was for neurosurgical applications, other specialties could subsequently utilize the scanner for their own purposes. They also state the implementation of guidelines for a less expensive route of treating certain types of brain tumors before proceeding to employ the use of the MRI.

Eskandar et al headed a long-term study of 1,761 patients diagnosed with Parkinson's disease that were treated stereotactically from 1996 to 2000. The surgical intervention for this study was performed at 71 different hospitals by 61 various neurosurgeons.[3] Functional neurosurgical

treatment varied from patient to patient. Sixty percent of the group studied received a stereotactic pallidotomy. A similar procedure, a thalamotomy, was performed on 6% of the group.[3]

Deep brain stimulators, a pacemaker for the brain, were implanted in 33% of the study group. This newer, less invasive treatment has become the gold standard of care of patients with Parkinson's disease. A reference frame was bolted to the patient's skull, and the frame and the skull were then scanned together to aid the neurosurgeon in placement of the electrodes deep in the subcortical regions of the brain responsible for motor movement.[3]

The mean age of the patients surveyed was 64 years, with ages ranging from 57 to 72 years. The complication rate was reported at 1.8% with subdural hematomas comprising 0.5% of the reported complications. There were four deaths reported within the group comprising 0.7% of the complications.[3] Deaths only occurred in institutions where the procedure is rarely performed. This is due to superior intra- and postoperative care in institutions that are familiar with the procedure, compared to that of an institution which performs one to two of these surgeries a year.

Cost analysis of the various procedures has been reviewed. The average length of stay of the patients was reported at two days.[3] Cost comparison was executed between the three types of stereotactic surgery surveyed. Deep brain stimulation (DBS) showed an increased cost because the cost of the device that is implanted into the patient is quite expensive. The total cost for DBS was $35,700, compared to the lesion generating procedure at a mean cost of $14,300.[3]

Hadani et al report on a new, innovative intraoperative MRI scanner, built specifically for intracranial neuronavigation. This MRI scanner, which conveniently fits under the operating room table, thus eliminating the need for transport of the patient to an MRI suite for imaging, is controlled by a neurosurgeon present in the sterile field.[4]

Although the MRI unit can be utilized in any existing operating room, some modifications must be undertaken to ensure the safety and quality of the patient and images respectively. Nonferromagnetic equipment, such as anesthesia machines and microscopes, that must be present in the room, are moved far enough from the magnet as to not to be drawn toward it. Standard surgical instrumentation may be utilized. However, MRI safe instrumentation is preferred because of the time and the traffic involved with moving the instruments to a safe location within the room. Copper shielding was placed behind the walls and ceiling of the operating suite to eliminate any radio frequency interference from the rest of the surgical services department.[4]

The navigational portion of this scanner is rather simple. A sterile wand is supplied with the system to locate the position of the resection margins in relation to the images acquired throughout the surgical procedure in real time. These images are viewed on a liquid crystal display (LCD) monitor in three planes: axial, coronal, and sagittal.[4]

Of the 20 patients included in the Hadani group study, 14 of the surgeries were craniotomies for tumor removal and six were transsphenoidal approaches to the pituitary gland. For the tumor removal group, the intraoperative MRI scan demonstrated the remaining tumor within the brain. This enabled the surgeons to remove the entire residual tumor seen by the MRI scan. Concerning the pituitary surgery, Hadani utilized the MRI navigation to aid the placement of the surgical speculum and instrumentation through the sphenoid and within the sella turcica. In addition, overall removal of the tumor was confirmed with the aid of the intraoperative MRI unit.[4]

As with any new piece of equipment, there is a learning curve associated with its use. This is especially true with this intraoperative MRI scanner. As the surgical team becomes more comfortable with the use of the equipment, the preparation and operative time is decreased. Hadani's study reported the average scan time added to the operative time was from 3.5 to 7 minutes.[4] No complications were reported with the use of the system.

Jane, Thapar, Alden, and Laws describe the use of a frameless stereotactic system to aid the surgeon into the sella turcica for a transsphenoidal resection of a pituitary gland tumor. The system used, the StealthStation® navigational system with FluoroNav™ virtual fluoroscopy system software, is manufactured by Medtronic Sofamor Danek. The system utilizes fluoroscopic images taken in the operating room to aid in navigation around the bony structures it has scanned. A relatively inexpensive system in comparison to others on the market, the system is easy to set up. The computer guides the surgeon systematically through the process of acquiring and manipulating the images received to create data that is useful to navigation. Utilizing the fluoroscope, information is relayed to the computer via a cable system. These images are registered to the patient using a reference arc mounted close to the skull.

A study group was created from 20 patients treated using this navigational system on 10 procedures and using standard fluoroscopy on the remaining 10 patients.[5] The average age of the patients in the group was 37.7 years. The types of tumors that were removed were, most commonly, pituitary adenomas and craniopharyngiomas. The mean set-up time compared between the groups was not noteworthy. FluoroNav surgeries were reported to be seven minutes longer than the standard fluoroscopic procedure.[5] Interestingly, the image-guided surgery times were 18 minutes faster than the traditional navigation. The accuracy of the system was also reviewed. Not one single imaged guided surgery had to be converted to a standard surgery. No complications were reported.[5]

The charges for billing were not significant between the two groups studied. The imaging guided platform added a cost of $310 per patient in operative time.[5] Another cost comparison was performed between the FluoroNav and

CT-guided frameless stereotaxy. The total cost of utilizing FluoroNav was reported at $324.10. The cost of using a frameless stereotactic system was determined to be $1,066.68.[5] This difference is due to the technical fee charged for using the computerized tomography scanner, the radiologist fee, and the increased set-up time in the operating room.

Kaakaji et al studied the potential consequences of stereotactic brain biopsy patients who were discharged early from the hospital. Utilizing the ViewPoint frameless navigational system, 139 patients were treated from January 1996 through July 1998. The mean age of the patients was 53 years. Each patient received a CT scan of the brain to assess any problems that may have arisen after biopsy. After the scan was cleared, the patients were then transferred to a nursing unit where they were observed for one day and then discharged.[6]

All the biopsy procedures were performed utilizing CT or MRI guidance with the application of an external stereotactic frame or the employment of a frameless system.[6] After administration of general anesthesia, a standard 7 mm burr hole was created in the patient's skull. Tissue specimens were obtained utilizing an average biopsy needle. Out of the group, 83% were diagnosed with a tumor. The remaining diagnoses included infection, stroke, and other neurological disease processes.[6]

Complications associated with this stereotactic brain biopsy were compared. Out of the study group, five patients developed a complication. The most common complication was a small hemorrhage formation at the site of biopsy. Only one of the patients suffered permanent neurological deficit. Deaths in three patients were reported, but they were not related to the biopsy procedure itself. Out of the 86 patients who received the stereotactic brain biopsy, 71 were well enough for same-day discharge.[6]

Economic analysis was directed toward hospital charges, net revenue, direct costs, and indirect costs.[6] Out of the patients surveyed, 96 records were available for review. Revenue decreased 14% in short stay patients and 45% in the extended observation patients.[6] A direct cost to the hospital was seen to increase 16% and 28% for each group studied. Profits were reported to be 6% higher in the extended outpatient group when compared to the short-stay group. Direct costs, however, were 35% higher.[6]

An abstract from Paleologos, Wadley, Kitchen, and Thomas on the use of image guidance during craniotomies for meningiomas reviewed 100 patients who had received surgery stereotactically and 170 patients who had received a traditional craniotomy. Although the operative times associated with the two groups were not significant, the image guided surgery group was shorter. Intensive care unit stay was also compared. Image guided patients were in the intensive care unit for an average of one day, while the traditional craniotomy patient's mean length of stay was 1.7 days. Mean total hospital stay was reported at 13.5 days for the traditional groups and 8.5 days for the image guided group.[8]

Complications were lower in the image-guided group when compared to the traditional surgery group, 6% to 14% respectively. The most common problem reported was that of hematoma formation. The average cost increase of surgery per patient was 20% higher for the traditional surgery group than the image guided surgery group.[8]

Cost analysis of stereotactic radiosurgery for metastatic brain lesions versus an open approach was surveyed by Rutigliano et al. The authors reported that radiosurgery for metastatic brain tumors showed a savings of $7,378 when compared to that of an open resection of the mass. A lower complication cost per case was also appreciated. This was studied by cost comparisons from five sites that were used for radiosurgery.[9]

Discussion

All the stereotactic systems reviewed have one similarity: They all provide for a safer, less morbid outcome than that of a standard "un-navigated" intracranial surgery at a lower cost to the patient and facility.

Although the concepts are the same when choosing a stereotactic navigational system, the purchase can be quite pricey. The least expensive system is a framed system. This design consists of a cylindrical ring that surrounds the patient's head and is held in place by literally screwing bolts that are that attached to the frame into the patient's skull. The frame is marked with specific coordinates measured in millimeters. These coordinates are used to help navigate the biopsy needle or probe into the depths of the brain. The frame and the patient are then scanned together in a computerized tomographic scanner. The images of the frame and patient are then used to give a trajectory to follow to allow the passage of instrumentation to its desired target.

The concept of this type of navigation is not new. The idea itself has been around since the late 1800s when a framed stereotactic ring was used to study the brain in animal models. It was not until the early 1900s that the idea had been brought up to use this new contraption in neurosurgery on human patients.

Framed surgery is still utilized quite frequently today in this age of super computers and silicon technology. Surgery for Parkinson's disease and other movement disorders are being treated successfully using framed surgery. An increasing number of institutions are recognizing the importance of combining minimal access surgery with stereotactic navigation. The fact that a patient can have outpatient brain surgery is no longer uncommon. It provides a means of increasing the patient satisfaction, while enhancing the standard of care and lowering the costs in this period of reduced reimbursements. Several patients have received this form of treatment, and it has proven itself nearly flawless. This type of biopsy system has given way to the next generation of stereotactic navigation.

A frameless navigational system incorporates the same principles, but involves a few other components. The initial purchase of the system consists of a computer platform, an infrared camera or magnetic field generator, and a referencing instrument. The computer is usually a high-speed platform that is capable of reproducing highly detailed images. The infrared camera basically is the eye of the system. In some systems, a magnetic field generator is used in place of the infrared camera. Both variations encompass the same goal, which is to provide a probe recognized by the computer.

In frameless navigation, the brain of the patient is scanned in a computerized tomographic scanner. Instead of a frame being bolted to the patient's head, special stickers, called "fiducials" are placed on the patient's skin. These fiducials are impregnated with barium sulfate to make them radiopaque. The fiducials are arranged in such a way that they surround the area to be operated. Surgeons place 7-12 fiducials on the patient to increase the accuracy of the system. Once the patient has been scanned, he or she is taken to the operating room to be prepped for surgery. The images obtained from the CT scan are then loaded into the computer, and a program is used to register or compare the fiducial markers on the screen with the ones that are on the patient. After the images and the patient are registered with the computer, the surgeon can proceed with the operation. Usually, a sterile probe is used to identify the surgeon's position in relation to the images acquired earlier that day. Some of the systems on the market provide instrumentation, such as suction tips and a clamp-on sensor, which allows the surgeon to use any instrument to aid in the navigation. The accuracy of this system is high; room for error is between 1-2 mm.

Frameless stereotactic navigation has become the gold standard in the surgical treatment of brain tumors. There are several factors to take in account when an institution decides to undertake a purchase of a navigational system. Obviously, the price is a major consideration. In the middle price range, a frameless system offers the surgeon an increased amount of flexibility when it comes to the surgical options. The system can be utilized for a biopsy, navigation, or even precise work, such as deep brain stimulator implantation for movement disorders, such as Parkinson's disease and spastic rigidity. Most systems on the market range from $150,000 to $200,000. This makes them affordable for the smaller, nonteaching institutions.

Some systems may be used with other surgical disciplines in mind. Otorhinolaryngological surgeons are using the stereotactic navigation technology to guide them into the intricate cavities of the paranasal sinus. Some of the systems on the market can be combined with other diagnostic modalities such as fluoroscopy.

Pituitary surgery, by tradition, has involved the employment of ionizing radiation images to guide the surgeon through the nose, sinuses, and eventually to the base of the brain where the pituitary gland resides. This technique carried an extra risk for the personnel in the room. Now, the surgeon can take just a few snap-shots with the fluoroscopic unit, load them into the stereotactic system, and use those images to guide the instruments into the brain, while eliminating the excessive exposure of X-rays to the personnel and patients. All of this is possible without a substantial increase in cost to the patient or the hospital.

The latest and most expensive of all stereotactic navigational systems is the intraoperative MRI. How can the expense of intraoperative MRI for navigation within the brain be justified? Even though the two previously described systems are very useful in brain biopsy and functional neurosurgery, neither account for brain shift. After the skull is opened and brain shift occurs, the images displayed on the computer screen from a scan earlier in the day are no longer accurate. The brain can shift, on average, 1-3 mm. The shift may not seem large, but when a neurosurgeon is operating on areas of the brain that control motor movement and speech, every micron counts.

Neurosurgeons often prefer MRI navigation to the other types when operating on brain tumors. Certain types of brain tumors, such as glioblastoma multiforme, are only visible on an MRI scan and not to the naked eye. The finger-like projections of this very aggressive and fatal type of primary brain cancer can only be detected by MRI.

Brain shift, tumor visualization, and the protection of vital areas of the brain show the importance of an intraoperative MRI, but these added benefits do not come without a profound cost. The average price of the MRI unit itself can range from $1-3 million, and does not include the cost of standard operating room equipment that is MRI compatible. This is not a purchase that most institutions encounter without some heavy funding and several years of planning.

Various additional expenses and considerations add to the larger picture. One consideration involves how the unit will be housed. Some institutions use the MRI in a standard operating room that has been converted for MRI use. Other hospitals use another dedicated room, outside the main operating room, to acquire the data. The latter makes the MRI accessible for diagnostic and other therapeutic procedures when neurosurgery is not being performed. On the other hand, the risks of contaminating the wound and sterile field increase when the patient must be transported with a loosely closed skull and scalp and placed into the scanner.

One manufacturer produces an MRI scanner that fits neatly under the operating room table and is raised and lowered as needed. This is especially beneficial since minimal alteration to the existing surgical suite is needed. During a scan, instrumentation and other ferromagnetic equipment must be moved out of the magnetic field, a few feet from the scanner. This advance in technology has proven to be an effective adjunct to the treatment of intracranial lesions.

The final type of stereotactic system is a radiosurgery system, or "knifeless" surgery system. This system utilizes radiation that has been specifically shaped or collimated to the shape of the patient's own tumor to destroy the tumor itself while preserving normal brain tissue. The most popular type of system utilizes a robotic arm that moves about the patient's head to approach the tumor from all angles. Although still in its infancy, radiosurgery has proven itself as the best choice of treatment for patients both with intracranial lesions that are easily operable and those that are inoperable. It has also proven to be a cost savings device when compared to the surgical systems surveyed.

In recent years, stereotactic intracranial navigation has become an accepted addition to the neurosurgeon's armamentarium. This has not come about without great controversy. Again, the price appears to be the primary factor. More institutions are being equipped with a guidance platform, because the accuracy of the system, a substantially lower complication rate, and the potential for a genuine outpatient surgery are realized when in comparison to a surgery without navigation.

Several companies manufacture stereotactic navigation systems on the market today. Each system possesses unique features. Some are adaptable for spinal applications. Others can be used with or without a frame. The main goal of all stereotactic navigation within the brain is to provide the surgical patient with a faster, more accurate, safer surgery, without morbidity or mortality, while decreasing the overall cost to the patient and the hospital. In the age of decreased reimbursement and managed care, this has never been more needed.

Conclusion

Every patient has the right to quality care when it comes to a surgical procedure. This includes the training of the surgeon, nurses, and other personnel directly involved with his or her treatment. Most patients overlook the type of equipment the surgeon will use to perform the procedure. Hospital administrators also tend to miss this detail. The employment of a stereotactic navigational system for intracranial surgery is a piece of equipment that has become invaluable in the operating room.

Traditionally, most neurosurgeons worked off the CT scans obtained preoperatively and the anatomy of the brain he or she sees on the operating room table. Although still very reliable, performing surgery this way carries an increased expense to the patient and the hospital, both economically and postoperatively. Stereotactic navigation provides the patient and the surgeon a means of receiving and performing a minimally invasive surgery while enhancing the accuracy and ultimately the outcome of the surgery itself. Surgeries on once unreachable areas of the brain are now possible by the use of a stereotactic system. Whichever system a hospital chooses, it is not a purchase that should go without careful research of the surgeons' needs. Also, it must be understood that the purchase of the system is not inexpensive, but the money saved in postoperative care and increased standard of patient care far outweigh the expense.

About the author

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Gynecologic Surgery Perioperative Considerations

BOB L CARUTHERS, CST, PhD

LEARNING OBJECTIVES:

- Indicate the factors that affect the outcome of pelvic surgery.
- Assess the preoperative workup of the patient undergoing gynecologic surgery.
- Recognize the pathologies discovered during the preoperative evaluations and their possible effects.
- Demonstrate an understanding of the various incisions that are employed in gynecologic surgery and the surgical steps for each.
- Recognize the special considerations and challenges of the obese patient.

A number of considerations concerning patient care apply to all patients and procedures, but some considerations exist that are of unique importance in the gynecologic setting. Since reproduction is essential to the species, there are personal, familial, and social implications in obstetric and gynecologic surgery.

Outcomes in pelvic surgery

The outcome of pelvic surgery depends on several factors. The following are worth noting:

- The physiologic vigor or the patient
- The surgical skill and knowledge of the surgeon
- The surgeon's knowledge of the disease process
- The resectability of the specific disease
- The status of the disease in terms of severity and reversibility

Notice that three of the factors are biological and may be beyond any control of the surgeon. While the physician will attempt to help the patient enter surgery in as good a physiologic condition as possible, the normal condition of the patient and/or the disease process itself may present conditions that increase the likelihood of negative outcomes.

Preoperative care

The CST or CFA is seldom directly involved with preoperative care outside the final operating room preparation; however, the only way to understand and predict the patient's and surgeon's needs is to understand the big picture.

Many women will use their gynecologist as both their specialist and primary care provider. Without regard to this, the initial examination should be thorough. Preoperative assessments, especially laboratory assessment, are intended to discover any medical problem or disease that might adversely affect the surgical outcome. At a minimum, the following laboratory test should be completed on every surgical patient: hemoglobin level, hematocrit, white blood count, differential blood count, and complete urinalysis.[1]

The importance of a good preoperative work-up is demonstrated in a study by Boyd and Groome.[6] The study focused on morbidity related to abdominal hysterectomy. The study included results from 102 hospitals and 3,322

TABLE 1 NORMAL ARTERIAL AND MIXED VENOUS BLOOD GASES[1]

Measurement	Arterial	Mixed venous	Note
Acid-base (pH)	7.35–7.45	7.33–7.43	Most important acid-base measurement
Partial pressure CO_2 (PCO_2)	35–45 mmHg	41–57 mmHg	Adequacy of ventilation and respiratory contribution to acid-base abnormality
Bicarbonate (HCO_3)	22–28 mEqL	42–28 mEqL	Metabolic contribution to acid-base abnormality
Base excess (BE)	-2–+2	0–+4	Indicates bicarbonate deviation from normal
Partial pressure of O_2 (PO_2)	80–100 mmHg	35–40 mmHg	Indicates pressure that is driving the bonding of hemoglobin and oxygen
Hemoglobin saturation (SO_2)	96–98%	70–75%	Identifies abnormalities in oxyhemoglobin association and disassociation
Hemoglobin concentration	15 g/100 ml	15 g/100 ml	Identifies gas transport abnormalities secondary to anemia
Oxygen concentration	19–20 ml/100 ml	14–15 ml/100 ml	Detects hypoxia

patients. Hysterectomies related to invasive cancer or complications of pregnancy were excluded from the study. In the study, the strongest predictor of postoperative morbidity was a preexisting medical disorder. The conclusion drawn by the researchers was that the major causes of morbidity in patients who undergo abdominal hysterectomy are medical, not surgical.[6]

We will now look at preexisting conditions that are of the most critical concern.

Pulmonary evaluation

Pulmonary complications remain a major concern in abdominal surgery. Normal blood gas values are presented in Table 1.

Preexisting pulmonary disease, especially chronic obstructive pulmonary disease, is a significant factor in operative and postoperative complications. In various studies, pulmonary complications have been reported as low as 5% and as high as 56% with lower abdominal surgery.[1] Sten et al found that chronic bronchitis and emphysema led to postoperative atelectasis and pneumonia at a 70% rate in comparison to a 3% rate for patients without these conditions.[1] Gold and Helvich found that patients with preexisting asthma had various operative and postoperative complications at the 24% level in comparison to 14% for the control group.[1] The most frequent conditions are those associated with chronic obstructive pulmonary disease (COPD, Table 2). COPD is caused by emphysema or chronic bronchitis and is highly correlated to smoking.[1] A high blood pressure may develop in the lungs and lead to a cardiac condition called cor pulmonale. Treatment is oriented to relief of symptoms.

While chronic obstructive pulmonary disease is the preexistent factor implicated for most operative and postoperative complications, other factors also contributed to pulmonary complications. These factors are age, smoking, chronic alcoholism, and operative site. The preoperative evaluation should be as complete as necessary according to preexistence symptoms or the physician's level of suspicion. An attempt to control as many of the negative conditions prior to surgery should be instituted. Routine chest X-rays are required prior to all surgical procedures.

Cardiovascular evaluation

Cardiovascular disease has received a tremendous amount of public attention in the United States. Success breeds success and new problems. No where is this more evident than in the treatment of cardiovascular disease. Tremendous advances have been made in both the medical and surgical approach to various diseases and conditions of the cardiovascular system. One of the products of this success, however, is that more and more patients live to an old age. These patients bring with them all of the factors attendant with age itself and the ongoing cardiovascular disease. Cadanelli et al reviewed 1664 gynecologic cases. They reported a 13.5% incidence of heart disease. The overall mortality rate was less than 1%.[1] These figures demonstrated the need for an adequate preoperative evaluation, early diagnosis, and medical intervention.

Coronary artery disease

Coronary artery disease is a major contributor to mortality rates in the US. The existence of coronary artery disease significantly increases the chance for operative and postoperative complications, and unstable coronary disease creates major concern. For many years, the data suggested that coronary artery disease was a disease of males and postmenopausal women. Recent data suggest that this is no longer a safe assumption, with the incidence of coronary artery disease growing in premenopausal women. Risk is increased in women over the age of 40 who take an anovulatory drug. Other risk factors are hypertension, hyperlipidemia, diabetes mellitus, and smoking.[1]

Diagnosis is made by a history of angina pectoris, documented infarction or ECG evidence of infarction. Two conditions of particular concern are congestive heart failure and the presence of premature ventricular contractions (PVC). Congestive heart failure refers to a condition in which the heart is unable to pump enough blood to meet the needs of other organs. Congestive heart failure may result from several conditions: coronary artery disease, previous myocardial infarction, hypertension, valvular disease, cardiomyopathy, congenital defects, and endocarditis.

PVCs are produced by an irritable area in the ventricles. They cause an irregular heart beat with a characteristic look on an ECG. PVCs have a tendency to come in clusters. They can lead to more severe rhythmic disturbances.

All unstable coronary disease, including infarction within six months, requires a team approach to treatment

TABLE 2 CHARACTERISTICS OF COPD TYPES[1]

Characteristic	Bronchitic type	Emphysematous
Body build	Stocky, obese	Thin, wasted
Age	40–60	Typically >50
Dyspnea	Sustained, progressive	Variable
Cough	Major symptom	Minor problem
Sputum	Generally profuse	Scanty
Wheezing	Episodic	Uncommon
Cyanosis	Common	Uncommon
PaO_2	Often low	Normal to slightly low
$PaCO_2$	Often elevated	Typically normal
Heart failure	Common	None
Respiratory failure	Frequent	Infrequent
Response to therapy	Good	Poor

and the delay of all elective pelvic surgery until the condition is stabilized.[1]

Valvular disease

Valvular disease presents another set of problems. Mitral valve prolapse is the most common valvular condition seen these days, and it occurs more often in women than men. In mitral valve prolapse, one or both valve flaps are enlarged. Flap support structures may also be elongated. As a result, the valves do not close smoothly or evenly, but are collapsed backward into the left atrium. This may allow small amounts of blood to leak back into the atrium.[1]

All valvular conditions require antibiotic treatment. Surgical repair is usually required. Since warfarin sodium is part of the typical regimen of treatment, it should be discontinued several days prior to surgery. Increased awareness and management of the anticoagulated patient is required both in the operative and postoperative period.[1]

Hypertension

Mild to moderate hypertension, uncomplicated by cardiac or renal disease, presents only low risk of complication. The medications used to lower blood pressure may present a problem for anesthesia. In the mild to moderate category, medications may be discontinued a few days prior to surgery. If diastolic pressure is in the severe range (>115 mmHg), medications should be continued through surgery.[1]

Thromboembolism

Three factors contribute to the development of thromboembolism: (1) hyper coagulability, (2) stasis, and (3) injury to a vessel wall. High risk factors should be evaluated preoperatively. Risk is increased under the following conditions: (1) malignant disease, (2) previous radiation therapy, (3) obesity, (4) severe venous varicosities, (5) leg edema, (6) acute and chronic pelvic infection and (7) use of oral contraceptives.[1]

Thromboembolism may manifest as calf vein thrombosis, proximal vein thrombosis or pulmonary embolism. A prophylactic approach may include elastic stockings, use of pneumatic sleeve devices, intraoperative dextran and early postoperative ambulation. Heparin may be used in cases of severe risk. Subcutaneous heparin and/or placement of a Greenfield filter may be used to protect against pulmonary or cerebral embolism.[1]

Gastrointestinal system

The gastrointestinal system should be routinely evaluated prior to pelvic surgery. Severe symptoms may require barium enemas or an upper GI series. Barium enemas or endoscopic studies may be required in instances of a positive stool guaiac. The close relationship between the bowel and gynecologic structures requires a special awareness of bowel preparation.

TABLE 3 ASA CLASSIFICATION OF PHYSICAL STATUS[2]

Class #	Patient Characteristics
P1	Normal healthy patient
P2	Patient with mild systemic disease
P3	Patient with severe systemic disease
P4	Patient with severe systemic disease that is a constant threat to life
P5	Moribund patient—not expected survive without the operation
P6	Declared brain dead patient—surgery for purpose of removing donated organs

Thorough mechanical cleansing of the bowel is essential prior to elective surgery. If entry into the bowel or resection is anticipated, a complete bowel preparation should be performed. This includes mechanical cleansing using an oral gut lavage solution administered until the diarrheal effluent is clear. Prophylactic antibiotics may be administered.

Urinary system

All patients having major surgery should be assessed for renal function with a serum creatinine and blood urea nitrogen studies. Any demonstrated or suspected dysfunction should be further evaluated and treated. Abnormal renal function changes drug metabolism and increases the odds of adverse drug reactions.[1]

Because of their close anatomic relationship, the urinary structures themselves may be affected by gynecologic disease, typically producing a partial or complete ureteral obstruction and secondary hydronephrosis. Lab studies and radiographic images should be part of the preoperative routine. Following a review of 493 cases, Piscitelli et al found that excretory urograms were appropriate in cases where clinical evidence of certain abnormalities existed.[1] The following represent those conditions: pelvic inflammatory disease, endometriosis, pelvic relaxation, uterine prolapse, and prior abdominal surgery.

Musculoskeletal and neurologic systems

Routine evaluations should be performed. Attention should be paid to any defects that increase the risk of complications secondary to the operative position that will be used.[1]

Anesthesiologist's classification of operative patients

It falls on the anesthesia provider's shoulders, sometimes assisted by other medical specialists, to manage the medical aspects of the surgical patient care. The American Society of Anesthesiologists developed a classification system that allows quick evaluation of the patient's global condition without regard to the medical complexity of some cases (Table 3).[2]

Preoperative routine

The preoperative routine in the operating room is familiar to all personnel and is included as a reminder that it is a period of stress for the patient (Table 4). These few minutes should be approached with professional awareness and seriousness. The personal, familial, and social implications of surgery on the reproductive system elevate the need for team awareness. One of the most overlooked areas is the use of language. It occurs because the O.R. team is comfortable in the environment and it's their fourth hysterectomy of the day. Ms Jones, however, is not comfortable, and this will be her one and only hysterectomy in a lifetime. For example, saying "Slide down until you feel the hole in the table," may frighten Ms Jones because she wonders if she will fall. Taking the time to explain the table and why you are asking her to move will calm many potential fears.[3]

Incisions for gynecologic surgery

An abdominal surgical approach requires at least one incision that involves the skin and appropriate musculature. Three general types of incision exist: vertical, transverse, and oblique. In the early days of abdominal surgery, the vertical midline incision, down the linea alba, was overwhelmingly preferred because it provided rapid access. With anesthesia in its developing stage, speed was a major concern for many surgical decisions.[4]

At the turn of the century, four transverse incisions were developed to allow better access to the pelvic area. These are known by the name of their developer: Küstner, Pfannenstiel, Maylard, and Cherney. Oblique incisions are rarely used in gynecologic surgery, and, when used, are usually to provide retroperitoneal access to nongenital structures. The incisions discussed here are for traditional pelvic surgery.[4]

Langer's lines

Langer mapped out cleavage lines in the skin. When skin is cut across these lines, the skin is pulled apart. In the abdominal region these lines are horizontal. As a result, transverse incisions run parallel to the Langer's lines and are under less tension. Generally speaking, transverse incisions in the abdomen produce finer scars. This advantage must be weighed against the fact that transverse incisions often produce a numb area immediately below the scar.[4]

Pfannenstiel incision

The Pfannenstiel incision is a transverse incision with a slight concavity that looks cephalad. The incision is usually 10-15 cm long and is extended to the level of the fascia of the rectus muscle. The incision can be made at any level the surgeon requires. Of all gynecologic incisions, it provides the most secure wound closure. The Pfannenstiel incision provides somewhat limited exposure. It should not be selected if any of the following exist:

- Known gynecologic malignancy
- Severe endometriosis
- Large leiomyomas that distort the lower ureter
- Reoperation for hemorrhage.[4]

The following steps are used for the Pfannenstiel:

- Make a transverse skin incision, 10-15 cm, with a slight concavity that looks cephalad.
- Extend incision to level of rectus fascia.
- Incise the rectus fascia on each side of the linea alba (beware of large lateral vessels and/or iliohypogastric nerve).
- Cut linea alba (connects to lateral incisions but leaves rectus fascia intact at the midline).

TABLE 4 BASIC PREOPERATIVE ROUTINE[3]

Action/intervention	Comments/notes
Transport	If hospital policy allows, the patient's family, or at least the most significant other, should be allowed to stay with the patient as long as possible.
Transfer	The patient is gently transferred to the operating table in the operating room or the anesthesia induction room. The team should remain relatively quiet during this time. When speaking, be careful not to use terms that might be misunderstood and could frighten the patient.
Anesthesia induction	If possible, induction of anesthesia should precede shaving and bladder catheterization.
Shaving	Generally, shaving is not required. When required, the lower abdomen, vulva, or both can be shaved after the induction of anesthesia. Time will not be wasted since it takes several minutes to reach a surgical level of anesthesia. A competent team can perform the tasks required within this time. The patient is spared some potential embarrassment and mild pain.
Bladder catheterization	Bladder catheterization is often required. This should be performed using the best of sterile technique.
Bimanual examination	This is the appropriate time for a bimanual examination of the pelvic structures to be performed. Since the patient is completely relaxed, the pelvic organs may be manipulated and appreciated to a degree not possible in the awake patient.
Prepped the perineum and vagina	Approved techniques should be carefully followed for this part of the preoperative preparation. For safety's sake, it is probably the best practice to prepare the vagina for all major abdominal procedures.

- The rectus sheath on each side is bluntly dissected from the underlying muscle in both cephalad and caudal directions (frees sheath as far as needed between symphysis pubis and umbilicus).
- Rectus muscles are separated in the midline.
- The peritoneum is opened vertically.[4,5]

Küstner incision

Sometimes incorrectly called a modified Pfannenstiel, this slightly curved incision begins below the level of the superior anterior iliac spine and extends to slightly below the pubic hair line. It is extended through the subcutaneous to the aponeurosis of the external oblique muscle and the anterior rectus sheath. This course may bring branches of the inferior epigastric artery into play. If encountered, they should be ligated. The need to secure certain hemostasis makes this a slow incision to develop. It has no particular advantage over the Pfannenstiel or low midline.[4]

Maylard incision

The Maylard incision is a true transverse, muscle cutting incision. All the layers of the lower abdominal wall are incised transversely. It provides excellent exposure and is often used for radical pelvic surgery. If a malignancy is discovered, the cosmetic value of the incision can be sacrificed by curving the incision into a J-shape, or by creating a separate upper abdominal incision.[4]

The Maylard incision is created through the following steps:

- A transverse skin incision is made 3-8 cm above the symphysis pubis (varies with age, weight, and surgical indication).
- The fascia is incised transversely, and the incision is carried laterally to the borders of the rectus muscle.
- Inferior epigastric vessels are identified.
- Vessels are bluntly dissected and ligated.
- The muscle is transected.
- The rectus muscle is bluntly dissected from the peritoneum.
- The muscle is transected using electrocautery.[4,5]

Cherney incision

The Cherney incision differs from the Maylard in that the rectus muscles are freed at their tendinous insertion into the symphysis pubis. The length of the Cherney incision is equivalent to a midline incision from the umbilicus to the symphysis pubis, plus 25%. The Cherney provides excellent exposure to the pelvic side walls. Like the Maylard, special care must be taken to avoid nerve damage.[4]

Midline incision

The midline incision has several features to recommend its use. It is the least hemorrhagic, provides speedy entry into the abdomen, can be extended easily, and risks minimal nerve damage. The midline incision is easier to develop in the parous woman, because the midline is easier to visualize. A midline incision may be more susceptible to dehiscence and hernia formation. When opening the abdomen of a woman who has a previous midline incision, it is a good practice to open the peritoneum cephalad to the prior incision. This reduces the chances of accidental incision into adherent bowel. The incision allows for inferior development of the Retzius space by extension through the pyramidal muscles.[4]

Paramedian incision

Paramedian incisions which may be further characterized as medial or lateral, appear to have greater strength. Study conclusions conflict on whether or not the paramedian or the midline season has more complications. It seems that the paramedian may be liable to more postoperative hernias. The paramedian incision is easily extended. Some problems associated with paramedian incision are increased infection rates, increased blood loss, increased operating time, and the possibility of nerve damage. If the paramedian incision is lengthy, postoperative pain may be increased by respiratory effort.[4]

Closure of vertical incisions

The vertical incisions present more problems for closure than transverse incisions, which are inherently strong. Paramedian incisions may require a layered closure. The midline incision should be closed by suturing the rectus muscles together. Many surgeons still prefer a layered closure for the midline incision. This approach is probably not necessary for most patients with gynecologic disorders. If a layered closure is used, however, sutures should be tied relatively loosely. The major cause of wound evisceration is too many sutures placed too close together and tied too tightly for closure of the fascial edge.[4]

In an effort to avoid this problem, some had advocated a Smead-Jones technique. This technique places sutures so that they alternate in a "far-far," then a "near-near" approach. Only the anterior fascia is included in the near-near stitch. A large-gauge suture such as a # 1 nylon or polypropylene is typically used. Success of this technique is dependent on the placement of the far-far stitches at 1.5 to 2 cm apart. While this is a strong closure, it is a time-consuming one and may not be appropriate for many cases. Others have advocated using a strong, nonabsorbable suture, taking wide bites through fascia, muscle, and peritoneum. It is not clear that any one approach is superior to the others.[4]

Oblique incisions

While not as common as the transverse or midline incisions, oblique incisions are of value in particular situations. Two incisions that may provide a good exposure for the gynecologic surgeon are the "gridiron" incision described by McBurney; and the Rocky-Davis incision. The gridiron incision is typically used for an uncomplicated appendectomy, the procedure for which it was designed.

However, it may provide excellent exposure for drainage of abscesses that are not accessible through the cul-de-sac. The Rocky-Davis incision is an alternative to the gridiron incision, and essentially has the same uses.[4] Both techniques are described below.

The steps for the gridiron incision are as follows:

- The skin incision is made obliquely and moved downward and inward, passing over McBurney's point.
- This incision is carried to the level of the external oblique muscle, which is separated in the direction of its fibers.
- The internal oblique muscle is identified and also separated in the direction of its fibers, as is the transverse abdominis.
- The peritoneum is identified and incised.

The steps for the Rocky-Davis incision are as follows:

- The skin incision is made in the transverse plane, intersecting an imaginary line, extending from the anterior iliac spine to the umbilicus, at a point approximately one-third of the way up the lower end.
- The medial point of the incision extends to the rectus muscle.
- The external oblique muscle is identified and split in the direction of its fibers.
- The internal oblique and transverse abdominus muscles are likewise identified and separated by blunt dissection in the direction of their fibers.
- The peritoneum is identified and incised.

Incisions—extraperitoneal approach

Patients with cervical cancer at advanced stages (IIB-IV) are often evaluated via a staging laparotomy to assess the paraaortic nodes. This operation has been proven to be of value in the past 20 years. Serious bowel problems have been shown to occur more often in a transperitoneal approach than in the extraperitoneal approach, when either is followed by radiation therapy. The advantage of the extraperitoneal approach is that if bulky pelvic nodes are evident or paraaortic nodes contain metastases, they can be removed without entering the peritoneum. Radiation therapy can then be provided with a reduced risk of bowel complication. The removal of the involved nodes also has been shown to increase survival rates. Two types of incisions to accomplish the extraperitoneal approach are explored.[4]

J-shaped incision

The J-shaped incision can be made on either right or the left. It is a modification of the extraperitoneal inguinal incision. The technique used for a right-sided J-shaped incision is as follows:

1. The skin incision is made vertically.
2. Begin just cephalad of the umbilicus and 3 cm medial to the iliac crest.
3. Upon reaching the iliac crest, this incision is continued medially approximately 3 cm and parallel to the inguinal ligament.
4. Fascia layers are then incised separately.
5. The extraperitoneal space is exposed by rolling the peritoneum medially and caudad.
6. The round ligament and inferior epigastric vessels can be ligated and transected to improve exposure.
7. The paraaortic area is then exposed by blunt dissection.[4]

Sunrise incision (right side)

A supraumbilical approach has been developed to allow for evaluation of the paraaortic nodes and earlier initiation of radiation therapy in instances where midline incisions threaten to delay the start of radiation therapy. This incision is called the sunrise incision. The sunrise incision may be initiated only on one side, typically the right. If a bulky mass or the need for more exposure is encountered, the incision is quickly modified into its full sunrise.[4] The following steps are used:

1. A transverse skin incision is made approximately 4 cm to 6 cm above the umbilicus.
2. The incision is carried laterally in a downward fashion to the level of the iliac crest.
3. The fascia is incised transversely.
4. The rectus muscles are dissected from their attachments to the anterior fascia and transected with a Bovie.
5. The deep epigastric vessels are found posterior to and in the center of the rectus muscle, and should not be exposed or ligated.
6. Bleeding should be controlled by electrocautery.
7. The transversus is identified, and its transaction initiated.
8. The peritoneum is retracted medially and cephalad.
9. The incision in the transversus is then carried more caudally and laterally, completing the transaction of muscle.
10. The retroperitoneal space can now be developed and the procedure continued.[4]

Obese patients—special considerations

The obese patient presents several problems for the surgeon and the anesthesiologist. This is particularly true if the patient is morbidly obese. There may be problems with both placement of the incision and wound closure. Obesity is a high risk factor for postoperative wound infection. One must be aware that transverse incisions involving muscle splitting may be slowed in their development.[4]

Midline approach in the obese patient

The protocol and technique recommended by Gallup is reviewed here:

- Patients must undergo preoperative showering and careful cleansing of the umbilicus.

- A mini-dose of subcutaneous heparin, 5,000 to 8,000 units, is given two hours before surgery. (This is continued every 12 hours postoperatively, until the patients are fully ambulating.)
- Prophylactic antibiotics are not routinely given.
- Abdominal hair is removed with clippers only.
- The panniculus is retracted caudally.
- The initial incision is made below the inferior margins of the symphysis.
- The incision is usually carried around, becoming a periumbilical incision.
- A wound protector is used to provide better exposure and to protect the skin edges.
- The fascial incision is extended to the symphysis.

The closure technique used includes the following:

- The vaginal cuff is closed.
- A closed drain is normally placed.
- The pelvic peritoneum is not closed.
- The fascia is closed.
- The subcutaneous tissues are irrigated with normal saline.
- A Jackson-Pratt drain is placed in the subcutaneous tissue.
- The subcutaneous tissue is not closed.
- The skin is closed with a suture stapler.

Panniculectomy and abdominoplasty

Another approach is to perform a panniculectomy and abdominoplasty. This removes the large panniculus prior to surgery and greatly improves exposure. This technique increases some risk factors, since two additional procedures are added to the gynecologic procedure. A plastic surgeon may be required for best cosmetic results. There are several surgical techniques that may be used to accomplish the objectives of this procedure. While research results have varied somewhat over the years, it appears that this approach is safe and effective, if the patients are carefully selected.[4,5] Patients should meet the following criteria:

- The panniculus must be large.
- Removal of the panniculus would greatly increase surgical exposure.
- The patient must receive counseling and be motivated to lose weight.
- If the primary procedure is not urgent, it should be delayed until a weight-loss of 40% to 50% of that required has been accomplished.
- During closure of the wound, meticulous detail must be paid to hemostasis.
- Excessive use of the electrocautery must be avoided.
- A firm Elastoplast®, crisscrossed bandage is usually applied over these incisions.[4,5]

About the author

Bob Caruthers, CST, PhD, served as former AST deputy director and director of professional development. He received his BA from the University of Texas, Austin, in 1972 and his PhD in 1995. He started his medical career as an emergency room orderly and was subsequently employed as a certified operating room technician. He later specialized in neurosurgery and developed a consuming interest in the human brain and its study.

He joined the faculty at Austin Community College and later moved to Colorado to work for AST. He was responsible for leading many significant efforts and was executive editor of the first edition of *Surgical Technology for the Surgical Technologist: A Positive Care Approach,* launched a program of educational CD-ROMs, was instrumental in the success of the AST National Conference and initiated the development of advance practice forums.

In January 2000, Bob was diagnosed with glioblastoma multiforme and faced his illness with strength and determination. In 2002, he lost the battle—and is still missed. This article was excerpted from his manuscript that was related to an OB/GYN advanced practice manual.

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Third-Party Reprocessing of Single-Use Devices In the Operating Room

JEFFREY J CORTESE, CST

LEARNING OBJECTIVES:

- Recall the defined medical terms as related to reprocessing of SUDs.
- Compare and contrast the benefits and disadvantages of reprocessing SUDs.
- Analyze the questions that are posed for deciding if reprocessing a SUD can be done.
- Analyze the issues that surround the controversy of reprocessing SUDs.
- Summarize the steps that are taken during the reprocessing.

Editor's Note: In an effort to keep our members informed of issues in the operating room, AST is providing two perspectives on the controversial topic of reprocessing. The use of single-use devices is just one of the topics that the AST Standards of Practice Subpanel will address in their work.

Health care costs continue to soar, while providers struggle to keep costs low. The operating room is no exception. The average charge for use of the operating room itself is in the range of $30-$35 a minute. This charge, combined with anesthesia, personnel, X-rays, and supply charges, can represent an enormous debt for a patient without insurance and for the hospital to tolerate. One way to combat these costs is to reprocess single-use devices (SUDs).

Not a new concept, the reprocessing of single-use devices can save the facility thousands of dollars in supplies, while maintaining a high standard of care for the surgical patient. In these days of lower reimbursements, escalating costs of supplies, and shortages of staff, reprocessing seems to be a very sensible way of saving money in the operating room.

With the emergence of third-party reprocessors, the Food and Drug Administration (FDA) has become more involved in the regulation of reprocessed single-use devices. Guidelines for reprocessing and regulatory requirements have been spelled out for these companies as well as for hospitals.

When an institution first considers implementing single-use device reprocessing, there will be opposition to the idea. However, instruments and other devices are reprocessed on a daily basis without an increased risk to the patient. Therefore, the reprocessing of devices labeled as "single use" can be utilized in the health care setting.

Review of literature

Belkin reported on the reuse of single-use devices as a matter of economics. According to the General Accounting Office, 30% of hospitals included in a survey are reusing single-use devices.[1] The benefits of reprocessing single-use devices are several. The cost of reprocessing is less than that of purchasing a new item. Belkin proposes that the transition from the era of single-use devices to those that are reusable might be one of the elements of change that will emerge during the US reform of the health care system.[1]

DEFINITIONS OF TERMS

Bioburden: The number and types of viable microorganisms that contaminate an article.
Clean: Removal of visible contaminants and environmental debris (eg, microscopic particles of tissue, body fluids, dust, body waste, dirt).
Opened but unused: Disposable devices for which sterility has been breached or compromised or the sterile package had been opened but not placed on the surgical field.
Opened but unused and contaminated: Devices placed on the surgical field that were not used during the procedure and are free from visible contamination (eg, tissue, blood, body fluids).
Reprocessing: Disassembling, decontaminating, cleaning, inspecting, testing, packaging, relabeling, and sterilizing single-use devices (SUDs) after they have been used on a patient for their intended purpose. Reprocessing also is performed on SUDs that had been removed from the package but not used on a patient or whose expiration date had passed.
Resterilization: The repeated application of a terminal process designed to remove or destroy all viable forms of microbial life, including bacterial spores, to an acceptable sterility assurance level. This process is performed on devices with an expiration date that has passed or that have been opened and may or may not have been used on a patient.
Single-use device (SUD): A disposable device, usually labeled as such by the original manufacturer, manufactured for single use and not intended to be reprocessed or reused.
Sterilization: Act or process that completely eliminates or destroys all forms of life, particularly microorganisms.
Third-party reprocessor: A business establishment, separate from the original equipment manufacturer and the user facility, whose primary business is to reprocess single-use devices.

An article surveyed in *Hospital Materials Management* showed that more institutions are deciding to hire third-party companies to reprocess single-use devices.[5] The article described a study in which the FDA surveyed hospitals with 250 or more beds on their particular reprocessing protocols. The survey showed that 45% of the hospitals reprocess single-use devices, and 84% of those hospitals employ an out-of-house reprocessing company.[5] Of all of the Veterans Hospitals in Texas, members saved a total of $25 million during the first year of implementing a reprocessing program.[5] Another health care system in Norfolk, Virginia, which is comprised of six hospitals, saved a total of $505,000 by reprocessing.[5] During the first year of utilizing a third-party reprocessing company, $90,000 was saved in Concord, Massachusetts, by utilizing a third-party reprocessor located in the state.[5]

In an article assessed in *Same-Day Surgery,* the FDA reported that 25% of all hospitals in the United States reuse single-use devices.[6] Of these devices, sequential compression devices comprised 15.8% of the items that are reprocessed. Drill bits, saw blades, burrs, biopsy forceps, and snares were some of the other items that were reprocessed.[6]

In an article published in *Biomedical Safety & Standards,* the FDA published the results of a survey regarding the reuse of single-use devices.[2] The article pointed out that hospitals with 100 beds or fewer (60% of the hospitals surveyed) tend to reprocess single-use devices in-house.[2] The survey also reported that 24.2% of all the US hospitals surveyed reuse single-use devices on other patients.[2]

Interestingly, *Healthcare Risk Management* published an article on what health care professionals thought about the reprocessing of single-use devices.[3] Out of the surgeons surveyed, three out of four believed that the reprocessing of single-use devices posed a threat to the surgical patient.[3] Seventy-nine percent of the nurses interviewed thought that the use of reprocessed single-use devices should be discontinued.[3] Out of the 82 nurses interviewed, 71% state that they would feel uncomfortable if a reprocessed single-use device was used on them or one of their family members.[3] Finally, the article pointed out that the patient population would expect to be informed about the practice of using reprocessed single-use devices at a ratio of two to one.[3]

In 2000, Janet Heinrich, associate director, Health Financing and Public Health Issues, Health Education, and Human Services Division, testified before the United States General Accounting Office on the reprocessing of single-use devices.[4] Her testimony focused on the extent of single-use device reprocessing, the health risks associated with the reprocessing, and the cost savings of reprocessing single-use devices. She pointed out that, after various surveys were conducted, 20% to 30% of American hospitals reuse at least one type of single use device.[4] One-third of the hospitals that took part in this survey employ third-party companies to reprocess the devices.[4]

Heinrich reported that the reprocessing of some devices could be 10% less than the same item purchased new from the company.[4] Her testimony identified only 13 third-party reprocessing companies in the United States. For these companies, $20 million per company was received annually for their services.[4]

Experts at the Centers for Disease Control (CDC) have proven that reprocessing of single-use devices poses a minimal health risk to the public. Of the hospitals that were surveyed, none received any claims of patient injuries resulting from the use of reprocessed single-use devices. Although the reprocessing of single-use devices is relatively safe, there have been a few incidents. A manufacturer in 1999 told the FDA that six reprocessed biopsy forceps used in gastrointestinal endoscopies were not sterile upon retrieval from one Florida hospital.[4]

William B Stoermer Jr published an article in *Medical Device & Diagnostic Industry* magazine on the debate of reprocessing single-use devices. Stoermer explained that reprocessing is a standard practice in the United States today.[7] As Stoermer explained, "Certain reusable instruments are often provided to the hospital on loan from a manufacturer. Although such devices sometimes arrive at the hospital packaged and sterilized, more often than not these manufacturer-provided instruments are delivered nonsterile by the company representative in the trunk of his or her car—just in time for the hospital to sterilize them for use in the surgical procedure for which they have been requested. Very seldom are biological indicators (BIs) run to assure the sterility of such loaner instrument trays, even though the bioburden level is totally unknown. Is this practice considered safe? If the answer is 'Yes,' then why not reprocess and sterilize the single-use saw blade or drill bit as well?"[7]

Stoermer posed the question, "Should all single-use devices be reprocessed?" He stated that there are usually no distinctions drawn concerning the risk of reuse of various devices.[7] When choosing what items can be reprocessed, keep this in mind: if the item cannot be cleaned effectively, then the item cannot be sterilized. The emergence of third-party reprocessors has raised the standards of what items are reprocessed and the manner in which they are processed.[7]

With regard to third party reprocessing versus in-hospital reprocessing, Stoermer pointed out major differences between the two.[7] These third-party reprocessors operate on a different level than the hospitals. These corporations are regulated by the FDA, while the hospitals are regulated by the Occupational Safety and Health Administration (OSHA). For all practical purposes, the FDA is more stringent on regulation than OSHA. However, the FDA's policy concerning third party reprocessing is still an unclear one, leaving some loopholes in the system. It states that the reprocessing of single-use devices is lawful as long as the company abides by all regulatory requirements enforced on them.[7]

Finally, Stoermer explained some of the benefits of reprocessing single-use devices. With the ever-present rise in health care costs, changes in reimbursement, and downsizing of staff, hospitals are forced to finds ways of increasing revenue without raising the price of the care.[7] One way of increasing revenue is by reprocessing disposable devices. After effective cleaning, testing, repackaging, and sterilization, these items can be used safely to help the patient.[7]

Discussion

Single-use devices in surgery are as common as suture material. Surgical drapes, gloves, gowns, sponges, and even some instrumentation are just a few examples of single-use devices in the operating room. Surgical drapes and gowns have always been reprocessed for multiple uses. Sponges and gloves, although reusable many decades ago, are now truly disposable items.

The majority of surgical instrumentation used in the operating room setting is reusable. For the item to be of single-use caliber, the quality has to be exceptional and the cost high enough to justify reprocessing. Reprocessing some items could save a department as much as half the replacement cost of purchasing a new item. For example, the average cost of a surgical saw blade used in open-heart surgery (sternotomy blade) is about $50. This disposable, high quality item is used once to make a cut into the sternum and then discarded. If an institution performs 300 open-heart surgeries a year, the cost for new saw blades from the manufacturer would total $15,000. Keep in mind, this cost is for one item that is used in one type of surgery and doesn't take into account the other types of surgeries that require the use of saw blades. Compared to the cost of reprocessing this blade, the cost for purchasing it new can be excessive.

Now consider the use of a reprocessed blade. The process begins in the operating room itself. The surgical technologist separates the items for reprocessing into special containers provided by the third-party reprocessor. These items are then sent to the central sterile department for cleaning. For example, used items may be cleaned by im-

Reprocessing of single-use devices is risky business

Teri Junge, CST, CFA, FAST

Is reprocessing single-use devices (SUDs) a risky business? Yes! Why? To answer this question, three main issues must be taken into consideration.

First, cross contamination must be considered. Single-use items are not designed to allow disassembly for proper cleaning, decontamination, and sterilization. According to Eucomed, recent studies show blood residue and dirt may be retained due to the difficulty/impossibility of cleaning single-use devices. Additionally, contamination from infectious particles, such as the prion that causes Creutzfeldt Jacob Disease (CJD) that are resistant to conventional methods of sterilization, may be present. The presence of pathogens puts both the health-care worker and the patient at risk.

Second, performance issues must be considered. Items intended to be disposable are manufactured to be assembled only one time and may not be capable of withstanding the conditions of disassembly, cleaning, reassembly, repackaging, resterilization, and reuse without compromise. Compromise—such as corrosion, distortion, a change in the pliability of the item, and other physical alterations, such as chipping and cracking—may occur when an item is exposed to various sterilization processes. The item's strength may not be sufficient to withstand multiple uses. This may cause the patient to suffer a poor, postoperative result, due to impaired performance, or experience a retained foreign body, due to breakage. Additionally, certain components of a disposable device may retain toxic residue from various resterilization processes. For example, an item originally sterilized utilizing ionizing radiation may be subsequently sterilized with ethylene oxide, which may cause toxic residue to be retained in/on the item. Reprocessing a single-use device will most likely void the manufacturer's warranty.

Third, legal/ethical issues must be considered. Do patients have the right to know that items intended for single use are being reused for their procedures? Should informed consent be obtained prior to use of such an item? What type of records should be kept on these items? Who will assume liability if a problem should occur?

The name alone, "single-use device," should offer the first indication that the devices are intended to be used just once. Several national/international organizations, including the International Association of Healthcare Central Service Materiel Management, AORN, and the British Society of Gastroenterology, have raised concerns in opposition to reprocessing of single use items. In Australia, an outbreak of hepatitis C virus, with a possible link to the reuse of single-use medical devices, caused 22 facilities to ban the reuse of reprocessed items completely. Further study and strict regulation of reprocessing protocol must be in place for this practice to be widely adopted.

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mersion in an ultrasonic bath. After the cleaning process, the items are packaged to be shipped out for reprocessing.

Upon arrival at the reprocessing facility, the items are bar coded, labeled and logged into the reprocessor's tracking system. This identifies the item's health care facility, departmental ownership, job number, and reprocessing history. After sorting, the items are manually and ultrasonically decontaminated. All processing data is saved in a database for future reference. For saw blades, the company uses computer-controlled methods that sharpen to the half micron. This method can also be applied to orthopedic devices, such as burrs and drill bits.

After the final inspection, the items are packaged for final sterilization. The labels on the package retain the printed barcode so the facility can trace the exact history of the item within. The items are then sterilized in ethylene oxide and shipped back to the correct department of the originating facility.

The turn-around time for a blade to be reprocessed is about two weeks. Once a facility builds an inventory of reprocessed items, the turnaround time will seem shorter because they will have an ample number of reprocessed items on the shelf. The cost of reprocessing each saw blade is $25. For this one item, used in one type of surgery, the overall annual savings would total $7,500.

Saw blades and orthopedic items are not the only single-use items that can be reprocessed. The most commonly reprocessed items are sequential compression devices. These sleeves, made of either plastic or fabric, are placed around the legs of patients who are nonambulatory. These sleeves inflate and deflate to massage the legs, thus decreasing the chance of a deep vein thrombosis or blood clot. Every patient scheduled in the operating room for more than one hour receives these sleeves. A majority of the time, these sleeves are discarded once the patient is discharged from the recovery room.

The amount of money saved by using a reprocessed sleeve, in comparison to purchasing a new sleeve, is very impressive. Institutions across the country are saving anywhere from $90,000 for a single hospital to $25 million for a state-wide health network. This savings can be applied to other areas of the department in need of upgrade or repair or can be used to purchase new technology or instrumentation. The possibility of saving money, while maintaining a high standard of care for the patient, is not an unrealistic one.

The FDA has become the driving force behind the third-party reprocessing companies in the United States. They have improved regulatory requirements placed on the third-party reprocessors, as well as hospitals that are reprocessing their own single-use devices. This major involvement has given the backing that the third-party reprocessors, which represent 85% of the reprocessing market, need since there are many institutions that frown upon reprocessing.

With regard to the acceptance of reprocessing of single-use devices, the numbers speak for themselves. After reviewing the money saved with reprocessing, along with education for the staff, it is easy to surmise that reprocessing single-use devices saves dollars. One must have an open mind when looking at the potential benefits of using reprocessed devices, since the quality of the processing is strictly regulated.

Conclusion

The current cost for a minor surgery to be performed would stagger most people who are not in the health care field. Combine this with the ever rising costs of equipment and supplies, lowered reimbursements and staffing reductions, one can easily deduce why a surgical services department would consider reprocessing single-use devices for multiple patient use.

Hospitals with an operating room in their facility process hundreds of surgical instrumentation on a daily basis. The majority of these instruments are of a solid metal design, such as a hemostat or scissors. However, many hospitals reprocess instruments and other devices made of other materials, such as plastic and cloth.

It is common for manufacturers to label products for single use. This action is mostly economically driven. Products have to meet certain FDA standards before they are made available for purchase. Those standards are the same for any product, regardless of whether that product is intended for single or multiple use. Therefore, the manufacturers are able to benefit economically by selling more products as single use items, than selling a product of the same quality labeled as a reusable item.

On a daily basis, instrumentation is reprocessed for multiple patient uses. Instrumentation with complex inner workings are effectively cleaned, checked, and sterilized to be used on the next surgical patient. A common example is the reprocessing of laparoscopic equipment. These instruments have several working parts, housed in a tube which allows passage into the body via small ports placed in the abdominal wall. These instruments have the capability of being broken down into a few parts. These parts are cleaned, rinsed, and reassembled for sterilization and, eventually, for use on the next surgical patient. Therefore, why cannot other items with the same characteristics as these instruments, be handled in a similar fashion? With the correct protocol in place for cleaning, disinfection, packaging and sterilization, items that were once considered disposable are being reused safely and at a substantially lower cost to the hospital.

To date, there are approximately 15 third-party companies that specialize in the reprocessing of single-use devices. These companies are strictly regulated by the FDA to ensure that the highest quality is adhered to during reprocessing. With the employment of a third-party reprocessor, a health care facility can save hundreds of thousands of dollars a year in supplies, as well as reduce the amount of bio-

hazard waste in our already diseased planet. These savings could be put to more beneficial uses, such as the purchases of new equipment, research, or community programs.

The outsourcing of nonclinical areas of the hospital is becoming a national trend. Companies that specialize in one area of the health care facility tend to be more productive, while maintaining or exceeding the existing quality of work. These companies assume all liability for the function, safety, and quality of the items they reprocess. The most obvious benefit of reprocessing is the potential for saving money.

To determine the potential savings of a reuse program, estimate the maximum number of times a device can be reused before it is discarded. A conservative approach is to divide that number by a reasonable safety factor of two. The maximum number of reuses, therefore, is reduced by one-half. Again, most of the savings associated with reuse are achieved in the first reuse cycle, with successive reprocessing yielding progressively decreasing savings. The potential risks associated with reusing SUDs provide sound rationale for minimizing the number of reuses, because the more reuse cycles performed, the greater the risk of adverse events occurring.

The most significant issue in evaluating a reuse program is patient safety. Before designing or implementing a reprocessing program, health care facilities must perform careful cost analyses to ensure that cost savings are realized. The steps involved in reprocessing (cleaning and inspecting, packaging, sterilizing, tracking, testing, validating) are numerous and complex. This process cannot be implemented casually. It must be controlled and vigorously monitored to ensure clean and sterilized reprocessed items are used.

Patient safety is paramount in all phases of reprocessing. Any item that cannot be guaranteed to be free from blood, fluid, body tissues, bioburden, or other contaminants should not be included in a reprocessing program. Policies and procedures should be established in measurable, objective terms to support each phase of reprocessing, and this process should be supported by senior management. Facilities are responsible for demonstrating that reprocessed devices continue to be safe, effective, and of high quality.

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Additional resources

- Janet Heinrich's testimony before the Committee on Health, Education, Labor and Pensions, US Senate on Medical Devices: Reprocessing and Reuse of Devices Labeled Single-Use is available online at www.amdr.org/documents/he00143tTestimony.pdf.
- Enforcement Priorities for Single-Use Devices Reprocessed by Third Parties and Hospitals published by the Food and Drug Administration, the US Department of Heath and Human Services, and the Center for Devices and Radiological Health is available online at www.fda.gov/cdrh/comp/guidance/1168.pdf.

Chronic regional pain syndrome: The facts with a patient's perspective

MARY SUTTON, CST, CFA, FAST

LEARNING OBJECTIVES:

- Distinguish among the types of CRPS.
- Recognize the symptoms of CRPS.
- Summarize the criteria for diagnosis of CRPS.
- Recognize the features of the three stages of CRPS.
- Compare and contrast the various treatments of CRPS.

Introduction

Chronic regional pain syndrome (CRPS), previously referred to as reflex sympathetic dystrophy (RSD), affects millions across the United States. This syndrome is often misunderstood and so most people do not know they have it. Weir Mitchell, MD, first described RSD during the Civil War. He found that certain veterans had "hot pain" after their primary injury healed. This happened most often with a wound involving a nerve injury. He called his syndrome "causalgia."

The Reflex Sympathetic Dystrophy Syndrome Association reports that CRPS is more common in women, which accounts for 75% of its patients. Sixty-five percent of the patients are in their 30s and 40s, although CRPS has been diagnosed in children and adolescents. In 30% of the cases, no precipitating cause is identified. CRPS has been ranked 42 out of 50 on the McGill pain index, making it one of the most painful chronic syndromes that exists. Researchers have found that CRPS occurs following: 1-2% of various fractures, 2-5% of peripheral nerve injuries, and 7-35% of Colles fractures. Unfortunately, for most patients, a diagnosis is not made early. Very mild cases may even resolve without treatment, while others progress until the syndrome becomes chronic and debilitating. Casting or immobilization can worsen the symptoms. CRPS can go into remission then come back after a further injury.

Types of CRPS

There are two types of chronic regional pain syndrome. Type I includes cases where there is no known nerve injury (this type is also referred to as RSD), and cases where the injury does not follow normal healing paths. The sympathetic nervous system (SNS) assumes an abnormal function after the initial injury. Even a minor injury, such as a sliver or an IV placement, can cause CRPS. Type II is also known as causalgia, where there is a distinct, major nerve injury. Again, the SNS assumes an abnormal function.

Symptoms

Symptoms of CRPS usually occur near the site of the injury. They include burning pain, muscle spasms, localized swelling, changes in skin temperature (which can be cold or warm), increased sweating, softening of bones, joint tenderness/stiffness, restricted and/or painful movement, and changes in the nails and/or skin which appear shiny red and later become bluish. The patient may have weakness and skin rashes in the extremity. There are often movement disorders with decreased muscle tone, tremor, difficulty starting a movement, and/or increased reflexes. The patient's pain is out of proportion to the injury and worsens in time. The patient often refers to the pain as burning, aching, or searing. The pain is continuous and increases with emotional distress and/or stress. Movement and being touched become intolerable. The patient's joints become stiff from disuse. The skin, muscle, and bones can atrophy. The patient may have extreme sensitivity to touch, which is called allodynia. There is also an increased perception of the pain called hyperalgesia. Misdiagnosis occurs because the symptoms are so individualized.

Some patients can improve without treatment. The greatest opportunity for recovery is with early recognition and treatment. CRPS is diagnosed primarily by observation of the symptoms.

Diagnosis

The criteria for diagnosis of CRPS Type I includes the presence of initial injury or cause for immobilization of the limb. The patient experiences continuing pain, allodynia, or hyperalgesia with pain disproportionate to the injury, if known. The extremity is edematous, with changes in the skin blood flow that cause both color and temperature variations. There is often abnormal or subnormal motor activity in the region of the pain.

The criteria for diagnosis of CRPS Type II is the presence of continuing pain, allodynia, or hyperalgesia post nerve injury, which is not necessarily limited to the distribution of the nerve.

There are three stages of CRPS (Table 1). Each has definite features, but patients often present with symptoms of different stages at the same time.

Typically, a diagnosis of CRPS is based on four common characteristics: intense prolonged pain, vasomotor disturbances, delayed recovery of function, and various trophic changes. Pain is the clinical feature that is considered the hallmark of CRPS and is the problem that prompts the patient to seek treatment. The pain may cause mobility problems disproportionate to the injury itself. All tactile stimulation to the skin is painful (hyperesthesia). There is diffuse

tenderness throughout the affected limb. Myofascial pain is caused by tender spots within the muscle due to the spasms. There can also be spontaneous "jabs" of pain.

As described previously, the skin is significantly affected by CRPS. The skin becomes dry, shiny, and at times scaly. Nails grow faster, then the growth slows, and nails become cracked. Rashes, pustules, and skin ulcers occur as CRPS progresses. The skin can be either warm or cold to touch. Often, the skin temperature reacts to the temperature of the room. The color of the skin can change from white mottled to red to blue.

Swelling is usually diffuse and localized to the painful region. Joints are often swollen and stiff. The extremity itself is difficult and painful to move. Decreased mobilization leads to more muscle atrophy than the syndrome alone causes. Muscle spasms, which can be severe, become debilitating.

As CRPS progresses, pain and symptoms become increasingly diffuse and, in approximately 70% of cases, spread to another limb. There are three types of spread. Continuity spread is to the upper or lower limb on the same side. Mirror image is spread to the limb on the opposite side. Independent spread is progression to a separate, distant region of body, which can be secondary to trauma in that area.

In some cases, there can be wasting of bones and osteoporosis. This is because CRPS can leech calcium from the bone and muscles. The duration of pain and the other symptoms of CRPS vary. A patient can have periods of remission of all symptoms and then exacerbation of those symptoms.

TABLE 1 STAGES OF CRPS

Stage I Time elapsed from precipitating incident—one week to three months

- Severe burning pain at the site of injury
- Muscle spasm, joint stiffness
- Restricted mobility
- Rapid hair and nail growth
- Vasospasms that affect the color and temperature of skin

Stage II Time elapsed from precipitating incident—three to six months

- Pain intensifies and becomes more diffuse
- Swelling spreads
- Hair growth diminishes
- Nails become cracked and grooved
- Diffuse osteoporosis
- Joints thicken
- Muscles begin to atrophy

Stage III Time elapsed from precipitating incident—until resolution or indefinitely

- Changes in skin and bone become irreversible
- Intractable pain
- Marked muscle atrophy
- Mobility severely limited
- Flexor tendon contraction
- Occasional limb displacement
- Marked bone softening

As trauma to the extremity has been discussed as an etiological factor, whether major (surgery/fracture) or minor (sliver, IV) is irrelevant. There are several other factors that should be discussed. CRPS has occurred in individuals with ischemic heart disease or patients having myocardial infarctions, cervical spine or spinal cord disorders, cerebral lesions, infections to the extremity, and repetitive motion disorders. As discussed, there are also patients with no known etiological event.

In order to understand the physiological cause of CRPS, one must understand the pain reflex. When there is an injury, a pain impulse is sent via sensory nerves to the central nervous system. The impulse triggers a reaction in the sympathetic nervous system (SNS), which travels, back to the site of the injury. At the site of injury, the SNS triggers an inflammatory response, causing vessels to spasm and resulting in swelling and pain. The pain then triggers another impulse to the brain which cycles over and over again. In a normal situation, the SNS stops functioning after a few minutes. In CRPS, the SNS assumes an abnormal function and the cycle continues. The vessels spasm, restricting blood to the muscles, which causes the muscles to spasm. Also, with the vessel spasms, there is the white skin response. Because of the redundant cycle, the long-term effects begin to show.

Unfortunately, there is no proven diagnostic lab test for CRPS; however, there are several studies that may suggest the disorder. Thermograms measure the heat emission of a limb. Usually there is an abnormal change in skin temperature of a CRPS patient, but a normal thermogram cannot rule it out. An abnormal test can be helpful evidence for judicial or insurance inquiries. A radionucleotide (three-phase) bone scan is a nuclear medicine scan, which studies the changes in bone structure. Some physicians use the scan as a tool to diagnosis CRPS. However, studies have found that the results cannot be validated as a definitive diagnostic tool. Doppler studies may also be useful in comparing asymmetrical bilateral blood flow.

Treatment

The CRPS patient needs the resources of many modalities for treatment. Pain centers throughout the country involve the services of occupational therapists, physical therapists, psychologists, and pain physicians. The patient needs to feel a part of the team and be involved in all aspects of their care. The most important part of the treatment is patient education. He or she must understand CRPS and the treatment options available.

Most patients need to know that someone understands their pain. The physicians involved must be knowledgeable about CRPS, as it is very individualized. A written record, such as a journal, may be helpful to review the

patient's progress. This protocol could include the procedures, medications, physical/occupational therapy, psychosocial issues, and tests, including results.

During this process, the patient should set reasonable goals for outcomes. The patient has to learn to overcome the natural tendency to maintain their disability. A pain psychologist is critical for optimal rehabilitation. The psychologist helps the patient improve his or her coping skills using relaxation techniques. Biofeedback or self-hypnosis may be used in this process. The pain psychologist must look at the psychosocial issues in the patient's life. They must evaluate the patient's pain-coping skills, as well as their drug-abuse potential. As stress is a known cause for exacerbation of pain, the patient's potential for committing suicide must also be considered.

Maintaining normal mobility of the affected limb is very important. The patient must avoid the automatic reflex to guard the painful extremity and not to use it. There are many modalities used to keep a patient mobile. Oral or transdermal medications may be prescribed. Transcutaneous electrical nerve stimulation (TENS unit) can be used to stimulate the muscles to keep them moving.

Physical therapy is the most important tool used to maintain mobility, and the therapist educates the patient on how to use the extremity. The "no pain, no gain" approach to physical therapy cannot be used, however, as that could cause the CRPS to worsen. The physical therapist must work with the patient to stretch and strengthen the affected limb, as well as work within the patient's pain cycle to avoid further damage. Different modalities—such as ultrasound, hydrotherapy, and massage—can be used to help treat the muscle spasms and weakness.

Occupational therapists are also used to help the patient use the affected limb normally in their work. Modalities such as desensitization are used to help the patient relieve some of the sensation of pain due to light touch. Occupational therapists work on fine motor skills to help the patient deal with everyday life. Just as the physical therapists are important for the continued use of the limb, the occupational therapists are also important in keeping the patient working and using that limb.

Sequential drug trials may be used as treatment. Medications are often "off-labeled," meaning that CRPS is not their primary modality. The dosages are gradually increased to determine the optimal dose for treatment. Different sequences of drugs may be used to create the desired effect. Patients should familiarize themselves with the possible side effects of each of the medications.

Medications are often prescribed according to various symptoms. Nonsteroidal anti-inflammatory drugs (NSAIDs, such as aspirin, ibuprofen, and naproxen) are given for constant pain with inflammation. In fact, certain studies have shown that CRPS may be alleviated within the first six months by NSAIDs alone. Tramadol, a

This is my story

In February 1997, one year and one week after carpal tunnel surgery, I experienced severe shoulder pain. I also noticed that my hand was cold and swollen. I went to my orthopedic surgeon, who told me that I had a cold in my shoulder and gave me some NSAIDs. I returned several weeks later with slightly different shoulder symptoms, but the same hand symptoms. After seeing him for eight months, he basically told me that he did not know what to do with me. His tone was that of disbelief. I was so discouraged!

On the advice of a friend, I spoke to one of our anesthesiologists who dealt with pain. We went to his office and he placed temperature strips on my hands. My left hand was 85 degrees; my right was 80 degrees. He told me the difference was normal for this syndrome, and gave me my first stellate ganglion block a week later.

I have had numerous stellate ganglion blocks, as well as three stellate ganglion RFLs. In October 1998, I had an endoscopic thoracic sympathectomy and was in remission for a year and six weeks. Since that time, I have had a couple of falls in the operating room. The first resulted in a pulled hamstring. The CRPS spread down that muscle only. The second resulted in a sprained ankle. Several months later, the CRPS spread down the rest of my leg.

My doctor tried to treat both areas by performing a thoracic sympathetic block at T-2 and T-3. I had several of them, as well as a thoracic sympathetic RFL. These were not successful, so I now receive a lumbar sympathetic block for my leg and a stellate block for my arm.

I currently take a number of medications to help control my RSD. Despite blocks and muscle relaxants, muscle spasms occur. I am still in pain, but can handle things better when I am mobile and taking medication. I have been through occupational therapy, as well as years of physical therapy, and will have many more years to come. I find it easier to keep my mobility by going to physical therapy. I am often chasing problems, such as tendonitis or limited movement with my arm, especially due to the muscle atrophy caused by my CRPS.

One thing that helped considerably was seeing a pain psychologist. I learned to focus away from my pain and deal with stress to prevent additional pain. Music also helps me deal with my pain. Listening to music, reading, and working helps me through the day without having a major perception of my pain. I have continued to work a full-time job with call, as well as one to two different part-time jobs. In addition, I have served on the AST Board of Directors. In fact, with my doctor's permission, I went to a Board meeting not even two weeks post sympathectomy.

Where do I go from here? I continue to keep doing what I am doing. I try to keep my muscles stretched and as strong possible. I work at a surgicenter, as well as take first assisting call for vitreoretinal surgeons. I keep myself educated on current CRPS trends and do what I can to educate others about this chronic pain syndrome. Hopefully, this education will benefit both surgical technologists and their future patients. Most importantly, I never give in to what I call "my beast." I cannot let it win.

central nervous system agent, may be prescribed for constant pain without inflammation. Constant pain and sleep disturbances are often treated with antidepressants, such as amitriptyline, doxepin, nortriptyline, or oral lidocaine (mexiletine), which is experimental. Paroxysmal pain (spontaneous jabbing pain) is treated with anticonvulsants, such as gabapentin or carbamazepine. For severe pain that is unresponsive to the previous drugs, an oral opioid (eg, morphine, codeine, etc.) may be prescribed.

Some studies suggest that a low dose of methadone to bind to a nonopiate receptor in the spinal cord, thereby reducing pain perception, may help CRPS patients. Any time a narcotic is used, a potential addiction hazard exists. A narcotics contract may be drawn up and signed. For muscle spasms, a variety of muscle relaxants may be used, such as cyclobenzaprine (Flexeril®), clonazepam (Klonopin®), tizanidine (Zanaflex®), or baclofen. A clonidine patch may be useful for SMP treatment. For localized pain due to nerve injury, capsaicin cream may be applied, although its effectiveness for CRPS patients has not been determined.

Sympathetic nerve blocks both diagnose and treat CRPS. A series of nerve blocks treat patients with CRPS that have sympathetic mediated pain (SMP). If the blocks prove effective, it is presumed that the patient was suffering CRPS. Other patients have sympathetic independent pain (SIP), which means their pain is due to something other than the abnormal function of the pain reflex, and the nerve block treatment is ineffective. SIP patients often are harder to treat, as it is more difficult to find the cause of the continued pain. Because of the ability to distinguish between the types of pain, as well as being a treatment protocol for SMP patients, sympathetic blocks are the most credible diagnostic tools for CRPS. With the type of pain established, the treatment process continues, if necessary.

Sympathetic blocks are often considered good treatment options. There are three reasons to consider a sympathetic block: permanent cure or partial remission of the CRPS, diagnostic information, and prognostic information for further treatments. A good sympathetic block provides increased temperature without increased numbness. The doctor should record the amount of pain relief and any improvement in the range of motion. The goal of sympathetic blocks is to treat but not to over treat. A series of multiple sympathetic blocks separated by brief intervals (eg one week) may be given to determine if these blocks are an effective treatment protocol.

The duration of pain relief and improvement due to a sympathetic block must be closely monitored by the patient and the physician. Patients with sympathetic mediated pain usually experience pain relief that far outlasts the local anesthetic duration (usually just a few hours). The extended pain relief and improved movement of the limb can last from days to months or put the affected limb into remission.

Some patients may not reliably report the effects of the blocks. One of the characteristics of a good sympathetic block is a feeling of warmth. Some patients may mistake this feeling as a relief or even a genuine perceived reduction of pain. Some patients deceitfully report pain relief as a means to get additional treatment and treatment options. Other patients feel that some kind of treatment is better than no treatment at all. The pain physician must be aware of this kind of behavior in order to act accordingly and in the best interests of the patient.

There are several types of sympathetic blocks: Stellate ganglion blocks are used to treat CRPS of the upper extremity. The stellate ganglion is located in the chest but the actual block is done at the level of C6-7 along the trachea. The patient is placed in the sitting position after injection to allow the anesthetic to settle on the stellate ganglion. Other possible features of a stellate ganglion block include Horner's syndrome, which is characterized by the flushing of the cheek and drooping of the upper eyelid on the side of the block. Because the block is done along the trachea, the recurrent laryngeal nerve may be affected for a short period of time. The patient experiences hoarseness and trouble eating and drinking. The block may cause numbness along the thumb side of the arm due to the C6 and C7 motor nerves. All these features resolve in a short period of time.

Lumbar sympathetic blocks are given for CRPS in the lower extremity. A C-arm is used to facilitate placement of the block needles. A catheter may be placed for a more specific block than an epidural block. A problem with the catheters is they are easily dislodged.

If a sympathetic block has been successful for a patient, the pain management doctor may try a radio frequency lesioning (RFL) of that area. The goal of RFL is to put the patient into total remission or at least to initiate a longer period of pain relief. The physician must verify, via fluoroscopy with contrast, that the RFL needle is in the correct position to ensure that no structures, other than the sympathetic root, are burned.

Epidural blocks can be used but are not very helpful for diagnosis or treatment of CRPS. Epidural blocks are less specific to the sympathetic nervous system. Most often, they are used to infiltrate steroids. The patient may experience temporary weakness in the legs, making walking difficult following an epidural block. Some doctors try to treat pain by placing a long-term epidural catheter. This has been found to be expensive with a greater risk of life-threatening conditions such as meningitis. Dislodgement of the catheter is also a problem. An epidural block with catheter placement necessitates a hospital stay of at least two days.

Chemical sympathetic blocks can be used as a diagnostic test for SMP. An intravenous sympathetic blocker, phentolamine, may be used to see if the pain is stopped. There is a 43% false negative rate, which makes this procedure rarely used. But it may be a valuable treatment in a situation where a block is not possible or when multiple extremities are involved. Phenol, however, is still used for sympathetic neurolysis in the lumbar region with somewhat good results.

Another technique is the injection of blocking agents into an extremity and limiting spread of the agent by a tourniquet. This procedure relies upon the ability to start an IV in a swollen extremity. There is no evidence that this technique is more effective than the sympathetic block, but it is an option for patients on anticoagulant therapy.

Spinal cord stimulators (SCS) have been used in the treatment of CRPS. They work well in patients with chronic intractable pain due to CRPS. The SCS provides low-intensity electrical impulses to trigger nerve fibers along the dorsal column of the spinal cord. The SCS is believed to stop pain messages to the brain. It replaces the pain with tingling. A temporary trial should be performed before the permanent stimulator placement. The stimulator should focus on the most painful region, which can be difficult for CRPS patients, whose most painful regions constantly change. It is an invasive, costly procedure that may not be covered by insurance. Potential complications of SCS are spinal infection and paralysis, but these are very rare.

CRPS may be treated with morphine pump placement. The pump would produce a single injection of morphine into the spinal fluid. Selective pain blocking occurs. It is also an invasive, costly procedure. There is no evidence of an advantage over oral morphine, though the pump does spare the patient from the side effects of taking oral morphine. Potential complications include tolerance, nausea, constipation, weight gain, decreased libido, edema in legs, and increased sweating. Pumps with baclofen may be used for patients with dystonia.

Another controversial procedure is sympathectomy. Kotzareff described the first open sympathectomy in 1920 for hyperhidrosis (abnormal sweating of the palms). An endoscopic thoracic sympathectomy was reported by Kux 50 years ago. It became widely accepted in the 1990s. Endoscopic, retroperitoneal, lumbar sympathectomy was first reported in 1993 with only preliminary results recorded at this time.

A sympathectomy disrupts the autonomic nervous system, resulting in interruption of pain pathways. It is used on patients with significant decrease in pain following sympathetic blocks. Only patients with SMP should be considered, as sympathetectomy is a very invasive procedure with risks. The procedure removes a section of sympathetic nerves located near the spinal cord. For CRPS in upper extremities, a sympathetectomy should be performed between T1 to T6 or T7. For lower limbs, it should be performed between L1 to L4. Sympathetectomy should be used for relief of CRPS, restoration of normal blood flow to the arms, and hyperhidrosis.

Complications of sympathectomy include bleeding, infection, and pneumothorax. Some patients experience compensatory sweating or gustatory sweating. Horner's syndrome is a common problem, due to the cutting of the sympathetic chain. In many cases, there has been sympathetic regeneration of the area that was cut.

Prognosis

With such diverse treatment options and individualization of the disease, there is no doubt that the CRPS patient has an uphill battle. There are many problems and effects of CRPS for the patient. Extreme pain, which is often a lifelong situation, is a way of every day life. This causes extreme family disruption and sorrow from family members, who are helpless to provide answers and pain relief. Often the CRPS patient is disabled or unemployed, which causes financial difficulties. Patients go through multiple misdiagnoses and strife from disbelieving health care professionals. Due to the misdiagnoses, the patient undergoes the improper treatment for CRPS. They have multiple surgeries, some of which will be unsuccessful. The quality of life they had is lost. Their health care costs are increased, and treatments may not be covered by insurance.

As the number of pain procedures being performed in the operating room increases, it is up to these professionals to familiarize themselves with chronic pain syndromes and how to take care of patients. Caregivers have to realize these patients are angry, frustrated, and in great pain. Ask the patient where to place EKG pads, what position causes them pain, and how to best touch them so they do not hurt. This allows the patient to relax in a stressful environment. Often these patients will have multiple visits to the operating room. Knowing their caregivers will treat them with respect and have an understanding of their pain syndrome goes a long way in alleviating preoperative stress.

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Surgery of the Head and Neck: Thyroid and Laryngeal Procedures

MARY SUTTON, CST, CFA, FAST

LEARNING OBJECTIVES:

- Distinguish the anatomy of the thyroid gland and parathyroid glands.
- Summarize the steps of a thyroidectomy.
- Summarize the steps of a parathyroidectomy.
- Recognize the laryngeal anatomy.
- Compare and contrast the various procedures of the larynx.

Thyroid and parathyroid anatomy

The thyroid gland is encased in the pretracheal fascia right above the trachea. The thyroid isthmus, which is the bridge between the lobes, usually straddles the first or second tracheal cartilage. A third lobe, called the pyramidal lobe due to its shape, may extend toward the head from the isthmus. This is important to remember when performing a tracheotomy, as the thyroid isthmus may either have to be bluntly elevated or transected.

The arterial supply to the thyroid gland comes from the superior thyroid artery, which is a branch of the external carotid, and the inferior thyroid artery, which is a branch of the subclavian artery. The points at which these arteries enter the thyroid gland are called the "poles" of the thyroid and are important anatomic landmarks. When performing a thyroidectomy, to preserve vocal cord function, the recurrent laryngeal nerve must be identified and protected. This nerve travels in the tracheoesophageal groove up from the chest and enters the larynx through the thyroid cartilage. Care is also taken to identify and preserve the parathyroid glands.

The parathyroid glands are typically four in number, but can vary from two to nine, and approximate the size and shape of a grain of rice. The parathyroid glands are most often found posterior to each pole of the thyroid gland; however, they can be difficult to locate because they can be found anywhere from the hyoid bone to the mediastinum. These glands are usually mustard yellow to caramel in color. They can be located within the thyroid capsule or even within the thyroid itself.

The recurrent laryngeal nerve is almost always medial to the parathyroid glands. The blood supply to the parathyroid glands is the inferior thyroid artery, but in some cases, the superior thyroid artery may also supply the glands. Because of the indefinite nature of parathyroid anatomy, a parathyroidectomy can be a very difficult surgery.

Thyroidectomy

Thyroid surgery dates back over 100 years. Removal of all or part of the thyroid became possible after the advent of general anesthesia and the development of hemostatic techniques. Theodor Kocher was the first surgeon to describe thyroidectomy in 1873. He wrote that it was important to avoid a total thyroidectomy, if possible, to prevent cretinism or myxedema. Kocher had successfully performed 900 cases by 1895, with a mortality rate of just over 1%.

Most thyroid tumors or nodules are benign and present as adenomas or thyroiditis. Cancer of the thyroid is uncommon, making up only about 1% of all cancers (8,000 to 9,000 cases each year in the United States). Women tend to have a higher rate of thyroid disease and that chance increases with age. Symptoms of thyroid disease include difficulty swallowing, stridor, or hoarseness. Patients usually present with some kind of mass, which is not tender and moves with swallowing. Children who present with a thyroid mass most often have a malignant tumor, especially if there is a family history of cancer. Exposure to radiation of the head and neck in early life increases the risk of associated thyroid cancer. Hoarseness may be a sign of a malignancy but also may occur due to a large thyroid adenoma pressing on the glottis.

Indications for thyroidectomy include:

- A child presenting with a mass,
- A mass after a history of radiation therapy as a child,
- Mass with elevated calcitonin level,
- A mass in a patient over 40,
- A mass with vocal cord paralysis,
- Positive lymph nodes in the neck.

A total thyroidectomy is performed if the mass is malignant. After a total thyroidectomy, the patient must take thyroid replacement hormone for the rest of his or her life. The surgeon will then decide whether or not to do a neck dissection, depending on the type of tumor and whether any nodes are present.

Before surgery, most surgeons may try to use fine needle aspiration to obtain tissue for biopsy to determine the diagnosis. Fine needle aspiration is relatively safe, cost effective and about 95% accurate, but may not be able to differentiate between an adenoma and a carcinoma. Patients with no evidence of malignancy from the fine needle aspiration may undergo thyroid suppression treatment. If the

size of the mass doesn't decrease with suppression, then the patient must have surgery.

Instruments needed for a thyroidectomy include a thyroid or neck set. The set should contain a pair of Green retractors, which are used to retract the strap muscles and were originally designed for thyroidectomy. Additionally, a Gelpi, a Weitlaner, or a Mahorner thyroid retractor may be needed.

Supplies needed for thyroidectomy include several packages of X-ray detectable 4″ x 4″ sponges and Kitner dissectors or peanuts. The surgeon will likely use a headlight and often, the assistant will as well.

The patient is placed in the supine position on the operating table with his or her neck extended. Surgeons usually prefer extreme extension of the neck, which allows for good visualization of the field. A shoulder roll may be used for this purpose. The patient is shaved, if necessary, and then prepped from the chin to the upper chest and bilaterally as far as possible. Routine thyroid or neck drapes are used.

Whenever possible, the surgeon will use a skin crease over the thyroid to make the incision. If no skin crease is visible, the incision will be 1 cm above the clavicle and to each edge of the sternocleidomastoid muscles. Often after the skin is incised, several anterior superficial veins will have to be ligated. A superior flap is dissected above the thyroid and an inferior flap is developed inferiorly to allow placement of the surgeon's preferred retractor.

The strap muscles are divided in the midline and undermined for placement of the Green retractors. Both lobes of the thyroid are identified and palpated. The trachea is also identified. The isthmus of the thyroid is better exposed and clamped, usually with heavy Mixter clamps, then divided. A heavy silk stick tie (eg 2-0) is used to tie off each end of the isthmus.

The thyroid is exposed laterally by blunt dissection of the strap muscles off of the lobe with a Kitner dissector. If any parathyroids are visible, they are dissected off of the thyroid. If a piece of tissue looks like a parathyroid, some surgeons may send it to the pathologist for a frozen section for identification.

The carotid artery is identified. The recurrent laryngeal nerve is usually identified before any major vessels are ligated. The nerve is commonly found in the triangle between the carotid, trachea, and the inferior pole of the thyroid. After the nerve is identified, any dissection to be made over the nerve should be blunt, using the scissors or a clamp. Once the thyroid is dissected off of the nerve, the inferior pole vessels are identified and ligated. This allows the surgeon to follow the nerve up to where it enters the larynx. Then the dissection is continued superiorly.

The superior pole vessels are identified and ligated, and the specimen is excised. The specimen is sent directly to pathology for a frozen section, in most cases to determine if there is a malignancy. The surgeon will achieve hemostasis and irrigate the wound while waiting for the pathology report. If a malignancy is detected, the opposite lobe will be inspected in the same manner. If no malignancy is found, the wound is closed. Some surgeons prefer to place a drain in the wound, usually a 7 mm flat Jackson-Pratt. Dressing is optional.

Tech tip: Some surgeons will close the incision and break before hearing the pathology report. It is important to leave the patient draped until the report comes back and the surgeon says the patient can wake up.

Complications of thyroidectomy include hematoma, recurrent laryngeal nerve injury resulting in vocal cord paralysis, hypoparathyroidism, and respiratory obstruction. If bilateral recurrent laryngeal nerve injury occurs, respiratory distress is noted postoperatively and can occur from minutes to hours after extubation. The patient may have to be reintubated or have an emergency tracheotomy.

Hypoparathyroidism occurs in 1%-5% of the patients, because the parathyroids have been removed, as they are difficult to distinguish from the surrounding tissue. If the patient has a total thyroidectomy, they experience hypothyroidism. They are given synthetic thyroid hormone treatment for life and often radioactive iodine treatment to treat the cancer.

STAGING OF LARYNGEAL TUMORS

T: the area the tumor takes up in the larynx

TIS	Carcinoma in situ
T1	Tumor confined to vocal cords with normal mobility
T2	Tumor extending to the supraglottis and/or subglottis with impaired vocal cord mobility
T3	Tumor limited to the larynx with vocal cord fixation
T4	Tumor invades through thyroid cartilage and/or extends to other tissue beyond the larynx

N: nodal metastasis

N0	no lymph node metastasis
N1	single node less than 3 cm
N2	single node 3-6 cm or multiple nodes less than 6 cm
N3	metastasis in node greater than 6 cm
Nx	nodes cannot be assessed

M: metastasis outside of the neck

M0	No distant metastasis (cancer has not spread to distant body structures)
M1	Distant metastasis (cancer has spread to distant body structures)
Mx	Distant metastasis cannot be assessed

Staging of laryngeal tumors

Stage I	T1 N0 M0
Stage II	T2 N0 M0
Stage III	T3 N0 M0
	T1/T2/T3 N1 M0
Stage IV	T4 N0 or 1 M0
	Any T N2 or 3 M0
	Any T, Any N, M1

Parathyroidectomy

Parathyroidectomy is performed for patients experiencing hyperparathyroidism, usually due to tumor. These patients present with hypercalcemia, high-normal or elevated fasting-serum parathyroid hormone levels, or calciuria in excess of 150 mg every 24 hours. Often there is a palpable mass or a mass seen on a CT scan. There should be no contraindications for general surgery for these patients. Instruments and supplies needed for parathyroidectomy are the same as for thyroidectomy, but the surgical team members should be prepared for numerous frozen sections for identification.

The patient is positioned, prepped and draped in the same manner as for a thyroidectomy. The incision is also the same as a thyroidectomy. The surgeon palpates for a mass through the strap muscles. If a mass cannot be palpated, the surgeon chooses a side to explore. The strap muscles and the thyroid lobe are dissected away. The middle thyroid vein may have to be ligated as part of the exploration and to take the thyroid out of the field. The thyroid is dissected away by finger dissection, from superior to inferior, under the gland.

The carotid artery, recurrent laryngeal nerve, and the inferior thyroid artery are identified and protected. The inferior thyroid artery is often used as a landmark for the superior parathyroids. The superior parathyroid glands usually lie above the junction with the nerve, and the inferior glands lie below.

The enlarged gland is identified and an effort is made to find other glands on the same side to make sure that they are normal. Once found, these glands are biopsied, usually with a hemoclip (as a marker). They are sent to the pathologist to ensure that they are normal. If another gland cannot be found, the surgeon may decide to explore the neck and even take out the thyroid gland to find it.

If another gland still cannot be found, the enlarged gland is taken out, the wound is closed, and the patient is watched postoperatively. For the first 24 hours, a parathyroidectomy patient should have the head of their bed elevated to 30 degrees to minimize bleeding in the operative site.

Anatomy of the larynx

The larynx separates the trachea from the upper aerodigestive tract. Its primary function is phonation, but it is also a regulator for respiration and prevents aspiration of food particles into the lungs. The larynx is necessary to produce an effective cough or create negative pressure through a Valsalva maneuver.

The framework of the larynx includes the hyoid bone, thyroid cartilage, cricoid cartilage, and the paired arytenoids. The hyoid bone provides attachment of the epiglottis, as well as several strap muscles, such as the sternohyoid and thyrohyoid. The thyroid cartilage has the anterior attachments of the vocal folds and articulates posteriorly with the cricoid cartilage. The cricoid cartilage is a complete ring and articulates with both the thyroid cartilage and the arytenoids. The arytenoids glide along the posterior cricoid and attach to the posterior ends of the vocal folds. With the strap muscles, the framework of the larynx aids in swallowing and respiration.

There are several divisions of the larynx. The glottis is the area within the larynx that contains the true vocal cords. The supraglottis is the area above the true vocal cords containing the epiglottis, the aryepiglottic folds extending from the lateral epiglottis to the arytenoids, the false vocal cords, and the ventricles (ie the area between the false vocal cords and the true vocal cords). The subglottis is the area below the true vocal cords extending to the inferior border of the cricoid cartilage. The trachea extends below the cricoid cartilage and serves as the passageway for air to the lungs.

The larynx and the pharynx are closely associated to just above the superior border of the cricoid cartilage. This is an important landmark for surgeons when performing laryngectomies, as it is important to keep the esophagus intact.

Laryngeal procedures

Most major surgeries involving the larynx and its associated structures are performed to excise cancer. Direct laryngoscopy or a CT scan often diagnoses the cancer. Laryngeal cancer is responsible for about 1.2% of all new cancers and about .73% of cancer deaths. A majority of the patients who present with this type of cancer are over the age of 60. The overall five-year survival rate for patients with laryngeal cancers is 67%. The risk factors for laryngeal cancers are tobacco usage (especially cigarettes), exposure to second-hand smoke, alcohol, occupational exposure, and radiation. Occupational exposures include asbestos workers, nickel workers, farmers, wood workers, painters who use lead paint, and machinists.

Squamous cell carcinoma (SCCA) represents 85%-90% of all cases of laryngeal cancer. The first symptom is a voice change, usually hoarseness, that doesn't go away. If unchecked, the cancer can cause airway obstruction. Some patients feel a fullness or discomfort in their throat. Often, in advanced stages of the disease, the patient will experience weight loss. Laryngeal cancer is more common in middle-aged males.

For smaller tumors, radiation therapy can often be the only treatment and offers a good chance of a cure. The patients should have a CT scan and MRI to detect the size of the tumor, the spread into surrounding tissue, and whether there is nodal disease in the neck. These patients must also be checked to see if there is any GI or respiratory cancers or spread of cancer. In addition, the patients must be thoroughly informed about the surgery, as their lifestyles can be dramatically changed. If the entire larynx is removed, the patient will have to learn to speak using esophageal speech. All patients will have a tracheotomy—some temporary and some permanent.

Instruments needed for laryngeal surgeries should include a neck dissection set. Some bone cutting instruments might be needed and should be available. If only performing a partial laryngectomy, a microsagittal saw will be used to cut through the cartilage. When doing partial laryngectomies, there may be frozen sections on the margins. Make sure that they are clear before closing the larynx. Several frozen sections may be processed. Lahey clamps are often used to grasp the hyoid bone and should be included on the surgical set up.

The supplies needed for laryngeal surgeries are the same as for neck dissections. Extra items include a saw blade for the microsagittal saw, tracheotomy tubes, and some kind of irrigation set up (eg a syringe with an Angiocat) to keep the field cool and clear of debris when using the saw. The size of the tubes is surgeon preference, but a rule of thumb is usually a 6 trach tube for women and an 8 for men. At least two of each size of tracheotomy tube should be in the room. The tube should be cuffed and nonfenestrated. This tube allows for healing of the larynx and trachea and also prevents blood from the wound getting into the lungs. Several days postoperatively, the patient will either be fitted with a cuffless, fenestrated tube to allow them to speak or have the tube removed entirely. This depends on the patient's ability to cough, as that helps prevent aspiration.

Supraglottic laryngectomy

SCCA makes up 95% of malignant supraglottic tumors. Supraglottic laryngectomy is highly effective for controlling localized disease and allows for near normal preservation of the voice and swallowing. All patients must sign the operative permit for a total laryngectomy, in the event that the margins of the tumor extend to the point where a supraglottic laryngectomy would be ineffective.

The decision to perform supraglottic laryngectomy depends on the size and location of the tumor. If it is a small, superficial tumor, the options for cure could be surgery or radiation therapy. If the tumor is more extensive, surgery is the only option. If the tumor involves the tongue base (which extends into the neck to the level of the hyoid bone) or hypopharynx, it is more likely to recur, and surgery with postoperative radiation therapy is performed. It is very important to check the margins in this surgery, as if there is a possibility of recurrence, then the best option is total laryngectomy.

The patient is positioned supine on the operating table with the neck extended, prepped and draped. A tracheotomy is performed right away or during the surgery. The surgical technologist should have a sterile endotracheal tube on the field to use as a temporary airway; a tracheotomy tube is placed at the end of the case.

An apron flap incision is made, and the flap is dissected upward and is sutured to keep the flap out of the way. The hyoid bone is skeletonized, which releases the strap muscles. The strap muscles are released downward to expose the thyroid cartilage. The perichondrium is elevated off the thyroid cartilage. The thyroid cartilage is cut with a microsagittal saw midway between the thyroid notch and its lower border. The saw cut is extended laterally to allow the surgeon to enter the hypopharynx and grasp the epiglottis. Mucosal incisions are made to incise the tumor and still leave adequate margins. The tumor is sent to pathology for a frozen section to determine if the margins are free of tumor. Hemostasis is achieved.

If the margins are clear, the tongue base is sewn to the glottis in a way that the mucosa of the tongue base is not approximated to the glottis but set back slightly. This helps decrease aspiration, as there is no epiglottis. The mucosa is closed in the periform sinus to lateral aspects of the tongue base. If there is not adequate perichondrium for attachment, holes may be drilled in the thyroid cartilage. The patient's head must be flexed to achieve closure. This decreases the tension on the sutures. The strap muscles are sewn back to their normal positions. Reinforce the initial closure by approximating the suprahyoid strap muscles to the infrahyoid strap muscles. Jackson-Pratt drains are placed and the incision is closed. Once the incision is closed, the tracheotomy tube is placed. A nasogastric tube is placed before the patient wakes up.

Postoperatively, the patient is fed through a nasogastric tube, as vomiting may disrupt the closure. Aspiration is rare postoperatively, as the vocal cords are swollen. Once the swelling goes down, the chance for aspiration increases. Six to 10 days postoperatively, the cuff on the trach tube is deflated, and the presence of the gag reflex is verified. If present, a cuffless trach tube is placed. If the patient tolerates the cuffless trach tube overnight, the tube is taken out completely (ie decannulation).

Before the patient is discharged, they must learn to feed themselves. The first oral feeding occurs under supervision, and the patient is taught the supraglottic swallow. This entails the patient taking a breath, closing the glottis with a Valsalva maneuver, swallowing, and coughing before inspiration. Pureed food is tried initially, and the patient is discharged once taking an oral diet, which is usually 14 to 17 days postoperatively.

Hemilaryngectomy

Hemilaryngectomy is the removal of half the larynx. This procedure was first performed in the 1880s and was popularized in the United States in the 1970s. Hemilaryngectomy is a vertical laryngectomy where one vocal cord is removed and the other cord is left intact. The hyoid bone and cricoid cartilage are left intact as well. The excision includes taking an anterior portion of the contralateral cord. Hemilaryngectomy is done for vocal cord tumors, which aren't likely to be controlled by radiation therapy alone. If the tumor involves the cricoid cartilage, though, hemilaryngectomy is contraindicated.

The instruments and supplies needed for a hemilaryngectomy are the same as for a supraglottic laryngectomy. Some surgeons may perform a direct laryngoscopy to make

sure that the tumor has not grown larger, crossed over to the other cord, and does not involve the cricoid cartilage. For this reason, the hemilaryngectomy patient must also give informed consent for a total laryngectomy.

The patient is prepped and draped the same as a supraglottic laryngectomy. The surgical procedure is much the same as a supraglottic laryngectomy, with a few key differences. The strap muscles are not taken off the hyoid, instead, they are dissected at the midline and retracted away. The perichondrium of the thyroid cartilage is opened at the midline and retracted away. The surgeon uses a sagittal saw to cut vertically through the thyroid cartilage. Some surgeons make a window in the cricothyroid membrane to look into the glottis and visualize their cuts. Once the window is made and the surgeon can visualize the field, the other cartilage cuts are made to remove the affected vocal cord and part of the opposite vocal cord.

Taking part of the opposite vocal cord ensures adequate tumor margins. The margins of the specimen will be checked, however, to make sure that the entire tumor is removed. The remaining vocal cord is reattached to the thyroid cartilage with a small absorbable suture. The epiglottis is sutured to the hyoid bone, and the perichondrium of the thyroid cartilage is closed. The surgeon will perform a tracheotomy sometime in the procedure and, after the wound is closed, the surgeon will place a cuffed, nonfenestrated trach tube. Most surgeons place a drain in the wound and a nasogastric tube before the patient wakes up.

About five days postoperatively, the patient is tested for decannulation. A cuffless trach tube may be used if the patient cannot tolerate decannulation. Once decannulated, the nasogastric tube is removed, and the patient resumes oral feeding.

Total laryngectomy

Total laryngectomy involves the removal of tissues from the hyoid bone to the cricoid cartilage. The base of the tongue, trachea, posterior pharyngeal wall, and cervical esophagus are preserved. Theodor Billroth performed the first total laryngectomy in 1881. There was a successful excision of the tumor, and the patient was rehabilitated with voice prosthesis.

Indications for total laryngectomy include malignant disease, radiation therapy failure, radiation necrosis of the larynx unresponsive to treatment, and severe irreversible aspiration (laryngectomy needed for separation of air and food passages). The patient must be a candidate for general anesthesia and be informed of the postoperative lifestyle change.

The patient will undergo a very thorough work-up before having a total laryngectomy. There must be a biopsied proof of malignancy. The patient will be screened for any airway and digestive tract tumors. The patient will have a CT scan to determine if there is any cartilage invasion of the tumor or metastasis in the neck nodes.

The instruments, equipment, and supplies needed for a total laryngectomy are about the same as for a supraglottic laryngectomy. The sagittal saw and the trach tubes are not needed. The entire cartilage framework is excised, leaving the trachea to be sewn to the skin as a permanent stoma. The sterile endotracheal tube will be used during the case to maintain the airway, as the original tube goes through the larynx and will be in the way. If the patient already has a tracheotomy present, then the anesthesiologist will place the endotracheal tube in the tracheotomy stoma, and the tube will be prepped as part of the field. Most surgeons prefer that the tube be sewn to the skin to prevent dislocation. This can be done before or after the prep according to the surgeon's wishes. Usually a 2-0 silk on a cutting needle is used.

The patient is placed in the supine position with the neck extended. An apron flap incision is made, and the flap is dissected upward and sewn out of the way. If there is nodal metastasis or a chance for metastasis, bilateral level II, III, and IV neck dissections will be performed. An anterior compartment neck dissection is performed as part of the laryngectomy.

Once the neck dissections are finished, the strap muscles are divided at the level of the hyoid bone. The hyoid bone is grasped with an Allis or Lahey and held upward to aid in the dissection of the strap muscles. Care is taken to make sure that the 12th cranial nerve is visualized off the lateral horns of the hyoid bone and not cut as part of the dissection. The dissection is carried through until the pharynx is entered above the epiglottis. The laryngeal framework is carefully dissected away, leaving as much pharyngeal mucosa as possible for a clear margin. The constrictor muscles are dissected away from the lateral plates of the thyroid cartilage to allow the cartilage to be freed up but also to allow easier exposure to the pharynx. As much mucosa as possible is salvaged to allow for a clear passage for food after closing.

The esophagus is dissected away from the trachea. This is often accomplished by the surgeon placing a finger in the esophagus and dissecting with scissors between the esophagus and the cricoid cartilage. The lower strap muscles are divided, and the thyroid lobe on the side of the tumor is removed. Of course, there is no need to preserve the recurrent laryngeal nerve when removing the thyroid, so thyroidectomy is easily accomplished by dividing its vessels.

The surgeon may take one or two tracheal rings to ensure a clear margin. The cut in the trachea is usually an angled cut to accommodate a larger stoma. The surgeon may perform a tracheoesophageal (TE) puncture to allow for feeding postoperatively and placement of an esophageal speech device after healing. This depends on whether or not the patient has had radiation therapy. If the patient has had preoperative radiation, then a TE puncture is performed before closing the esophagus and pharynx, and a soft nasogastric tube (eg Levine tube) is placed through

to the stomach. If a TE puncture is not performed, a nasogastric tube will be placed through the nose into the stomach.

The pharynx is usually closed with an absorbable suture (eg 3-0 Vicryl®) on a taper needle. The tracheal stoma is pulled up and stabilized by suturing it to the periosteum of the clavicle. Jackson-Pratt drains are placed, the skin is closed, and the tracheal stoma is sewn to the skin. There is no need for a trach tube because aspiration from food is no longer possible, as the airway is now separated from the esophagus.

Complications of total laryngectomy include drain failure, which can be a serious threat, hematoma, and infection. A pharyngocutaneous fistula is a complication, which presents about one to six weeks postoperatively. The fistula starts as a salivary leak into the subcutaneous space and progresses to form the fistula tract. Management of the pharyngocutaneous fistula includes packing and antibiotics. The patient is allowed nothing by mouth. For larger fistulas, which do not heal well, a muscle flap may be needed to close the fistula. Stomal stenosis may also occur, but can be repaired by a stomatoplasty. The pharynx may also become stenotic due to the surgery and may have to be dilated.

Conclusion

Cancers of the head and neck can have devastating consequences for patients. Skill and knowledge of the surgical treatment of these diseases are key to quality patient care.

About the author

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Abdominal Aortic Aneurysm Resection

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LEARNING OBJECTIVES:

- Recognize the anatomy of the aorta.
- Evaluate the pathophysiology and pathogenesis of abdominal aortic aneurysms.
- Recognize the symptoms of AAA.
- Indicate the diagnostic procedures that are performed to confirm the presence of AAA and its size.
- Summarize the surgical care of the patient including the steps of the procedure and potential complications.

The term aneurysm originates from the Greek aneurysma meaning, "a widening." An aneurysm is a localized, abnormal dilation in an artery, resulting from the mechanical pressure of blood on a vessel wall weakened by biochemical alterations.[8] As the vessel wall becomes progressively weaker, the aneurysm gradually enlarges, and the risk of spontaneous rupture increases. An aortic aneurysm can also be described as a local dilation of the aorta, involving a minimum 50% increase in diameter.[6]

Abdominal aortic aneurysm (AAA) resection is the surgical obliteration of an aneurysm that may or may not include the iliac arteries, with the insertion of a synthetic prosthesis to re-establish functional continuity.[7] The majority of AAAs begin below the renal arteries and may extend to involve the bifurcation and common iliac arteries.[27]

Approximately 200,000 new AAA cases are diagnosed each year, and 40,000 surgical repairs are performed.[1] Thirty percent of AAAs will rupture, leading to an 80% mortality rate and 9,000 US deaths annually.[14]

There are essentially three surgical approaches to AAA repair:

- traditional invasive surgical intervention, involving an abdominal (transperitoneal) approach
- retroperitoneal approach
- AAA repair utilizing the endovascular graft

This article focuses on the traditional approach to AAA repair, utilizing the transperitoneal approach during elective surgical intervention.

Historical perspective

Aneurysms have been identified since 2000 BCE when the Ebers Papyrus, one of the earliest known medical texts, described traumatic aneurysms of the peripheral arteries.[22] Antyllus, who reported the first elective operation for treatment of an aneurysm in the second century, recommended ligating the artery above and below the aneurysm, incising the sac, evacuating the contents, and closing the aorta by granulation.[22]

The 16th century anatomist Andreas Vesalius documented one of the first descriptions of an abdominal aortic aneurysm.[17] Alexis Carrel (1873-1948) demonstrated in animals that a segment of aorta could be replaced with a piece from another artery or vein and successfully anastomosed to other blood vessels. His contributions helped establish modern techniques of blood vessel anastomosis and suturing techniques that would be linked to successful vascular surgery.

In 1888, Rudolph Matas (1860-1957) developed the surgical technique of endoaneurysmorrhaphy, which involved clamping above and below the aneurysm, opening it, ligating the branches, and then buttressing the wall with imbricated sutures.[28] Meanwhile, other clinicians were attempting to induce thrombosis of AAAs by inserting intraluminal wires.[25] Matas performed the first successful aortic ligation in a patient with an AAA in 1923.[19]

In 1948, C E Rea wrapped cellophane around the neck and over the antereolateral surface of an aneurysm to induce a fibrotic reaction and limit expansion of the aneurysm.[26] In 1949, Rudolph Nissen utilized Rea's surgical technique to treat Albert Einstein's symptomatic AAA. Einstein survived six years before succumbing to eventual rupture.[3]

It was not until March 29, 1951, that Charles DuBost published the first account of successful replacement of an aneurysm with a freeze-dried homograft.[4] Additional advances in vascular surgery would come in 1957 when DeBakey and colleagues introduced knitted Dacron® grafts, providing the first effective synthetic vascular graft material.[12]

Anatomy

The aorta is a large artery which is the main trunk of the systemic arterial system. It originates from the left ventricle as the thoracic aorta and ends at the left side of the body at the level of the fourth lumbar vertebra, where it divides to form the right and left common iliac arteries. The aorta is comprised of the ascending aorta, the aortic arch, and the descending aorta, which is divided into the thoracic aorta and the abdominal aorta.[5]

Aneurysms are defined as a focal dilation at least 50% larger than the expected normal arterial diameter. A common definition of the AAA is a transverse diameter of at least 3 cm and, for a common iliac aneurysm, a transverse

diameter of at least 1.8 cm.[24] Pearce and colleagues documented that normal aortic diameter gradually decreases from the thorax (28 mm in men) to the infrarenal location (20 mm in men). At all levels, normal aortic diameter is approximately 2 mm larger in men than in women and increases with age and increased body surface area.[24]

Several arteries branch off of the abdominal aorta, distributing blood to various organs (Table 1). The aorta is critical to normal circulatory function.

Pathophysiology/pathogenesis/classification

Aneurysms are typically classified according to their location, size, shape, and etiology. They are most likely to form at bifurcations, where the artery is subject to frequent bending with physical activity and is not well supported by muscle. In response to intraluminal pressure, the weakened vessel may balloon out on one side (saccular aneurysm) or may enlarge circumferentially in a spindle shape (fusiform aneurysm).[11] The third type of aneurysm is a dissecting aneurysm, which occurs when a small tear of the inner arterial wall allows blood to form a pathway between layers of the arterial wall.

Saccular, fusiform, and dissecting aneurysms are known as "true aneurysms." By definition, aneurysms represent a dilation of all layers of the arterial wall.[28] Some confusion exists in reference to the definition of a false aneurysm or pseudoaneurysm. Pseudoaneurysms have often been described as an aneurysm that does not involve all layers of the arterial wall.[28] False aneurysms (pseudoaneurysms) are not arterial aneurysms, as they do not contain any layers of the arterial wall. Pseudoaneurysms are contained hematomas that result from localized arterial trauma, such as that which occurs during angioplasty.

The shape of an aneurysm is commonly described as saccular verses fusiform. In general, saccular aneurysms are believed to have a higher risk of associated rupture.[32]

Aneurysm size is described by diameter and length, with diameter being the critical risk factor for rupture. AAAs enlarge slowly over the years at an approximate rate of 0.2-0.5 cm per year.[15]

Evidence suggests that AAAs are not caused by atherosclerotic disease, but an aorta with atherosclerosis may be more prone to aneurysm. An early hypothesis that hypertension causes AAAs has not been adequately proven.[14] Smoking and advanced age are the risk factors most strongly associated with AAA.[15]

Lifestyle factors commonly believed to increase the risk of AAA development are the same as those believed to increase the risks of other forms of arterial disease, such as peripheral vascular disease and coronary artery disease. Risk factors for AAA include the following: smoking, diabetes, high cholesterol, family history of AAA, gender (higher incidence in men), and age (men over the age of 55, women over the age of 70). Other risk factors include uncontrolled hypertension and high blood cholesterol levels.[9]

TABLE 1. BRANCHES OF THE ABDOMINAL AORTA[31]

Branch of the abdominal aorta	Organ supplied
Inferior phrenic arteries	Diaphragm
Celiac arteries: hepatic artery, left gastric artery, splenic artery	Liver, stomach and esophagus, spleen, pancreas
Superior mesenteric artery	Small intestines, cecum, ascending and transverse colon
Suprarenal arteries	Adrenal glands
Renal arteries	Kidneys
Gonadal arteries	Testes or ovaries
Inferior mesenteric artery	Transverse, descending and sigmoid colon and rectum

A genetic tendency has been shown to be associated with the development of AAA.[29] Screening recommendations are currently being reviewed to facilitate diagnosis of asymptomatic AAA, so that elective repair can be undertaken prior to rupture.[33] Other inheritable causes of AAA are connective tissue disorders, such as Marfan's syndrome and the Ehlers-Danlos syndrome.

Epidemiology

AAAs are generally perceived to be a disease of elderly white males. AAAs increase steadily in frequency after 50 years of age, are five times more common in men than in women, and are 3.5 times more common in white rather than African American men.[13] The reported incidence of AAA varies from three to 117 per 100,000 persons.[33] In men, AAAs reach a peak incidence near 80 years of age. In women, AAA onset is delayed until an estimated 60 years of age, with a continuing rise in incidence.[33]

Clinical manifestations

AAAs are usually asymptomatic and may be discovered on routine physical examination. Some AAAs are detected when the patient undergoes diagnostic testing for other conditions, such as an ultrasound examination for urological problems.

Symptoms of AAA are often vague and nonspecific but usually center around back pain and abdominal pain. The intact aneurysm is asymptomatic until it becomes large enough to be detected as a pulsating mass creating pressure on surrounding organs.[11] The severity of symptoms will intensify as the aneurysm increases in diameter. Intravenous pyelogram, CT scan, abdominal X-ray, and ultrasonography are several diagnostic procedures that will detect the enlarged arterial wall and identify the location and size of the AAA.[18]

Severe back pain, shock, distal vascular insufficiency and symptoms of hypotension usually indicate rupture and represent a true surgical emergency. Pain is usually the most consistent finding in an impending rupture, and

the patient may describe pain in the abdomen, back, flank, or pain radiating to the chest, groin, or legs.[20] Hypotension may be absent when a leaking or ruptured aneurysm has been contained in the retroperitoneum.

Less common symptoms present when the aorta ruptures into the duodenum (GI bleeding) or inferior vena cava (lower extremity edema, and congestive heart failure). AAA symptoms may mimic more common disorders such as renal colic, disk disease, myocardial infarction, and other acute abdominal conditions.[20] When an aortic rupture is suspected or actually occurs, the primary consideration of the surgical team should always be hemorrhage control.

Diagnosis

Medical management is indicated for the AAA that is less than 4 cm in diameter. Medical management of AAA would include periodic size measurements of the aneurysm, encouraging smoking cessation and, if present, the aggressive control of hypertension. "Despite initial promising results from retrospective analyses, beta blockers have not been shown to slow the rate of growth of AAA in subsequent randomized trials, but doxycycline seems more promising."[37]

If medical management is unsuccessful in controlling the diameter of the aneurysm and it increases in size, surgical repair is recommended at 5 cm or greater.[30]

Ultrasonography is utilized to confirm the presence of the AAA and to track aneurysm enlargement without exposing the patient to radiation. Computed tomography (CT) may be used to screen patients and to also detect factors that may contribute to the planning of the AAA surgery. CT scanning can provide accurate size determination and also information regarding the proximal and distal extent of disease. Spiral CT scanning is a more rapid method of CT scanning that provides excellent resolution, three-dimensional reconstruction, and user-friendly images, all of which facilitate more accurate measurement for graft sizing.[28]

Magnetic resonance imaging (MRI) is comparable in accuracy to CT scanning without radiation exposure. MRI provides valuable information in reference to renal and mesenteric involvement. Arteriography may also be used as a method of diagnosis and is beneficial in evaluating any obstruction of the iliac and femoral arteries.

Preoperative preparation

Hemodynamic monitoring is imperative in the accurate assessment of the patient's circulatory status. Monitoring devices may include central venous pressure monitoring as a guide for fluid replacement, an arterial line for blood pressure management and arterial blood gas analysis, and a Swan-Ganz pulmonary artery catheter to assess pulmonary artery pressures, cardiac output, and left ventricular function. Oxygenation of the patient's arterial blood is monitored by pulse oximetry.

Typed and cross-matched blood should be readily available prior to the start of an elective AAA repair. Autotransfusion (Cell Saver®) can be used intraoperatively to allow autologous transfusion and is essential if massive hemorrhage is encountered, such as with a ruptured AAA.

The hyper-hypothermia unit should be utilized to maintain the patient's core body temperature during the surgical intervention. A Foley catheter is inserted preoperatively to monitor urinary output and renal function.

An audible Doppler device is routinely used to assess blood flow through a vessel, especially when the pulse cannot be palpated manually. Blood flow in the extremities should be checked for embolic or occlusive problems preoperatively and postoperatively.[8] The exact location of the pedal and dorsalis pedis pulses may be identified and marked with a surgical marking pen to facilitate an intraoperative pulse check upon the surgeon's request.

Patient preparation

The patient is placed in the supine position for the transperitoneal approach with both arms extended and secured on arm boards. The skin is prepped from the axilla to the knees and bilaterally as far as possible to accommodate a midline abdominal incision.

An alternative method of surgical skin preparation may require that both of the patient's legs be prepped circumferentially to allow for the possibility of lower extremity arterial exploration and bypass. This alternative method of the surgical skin preparation may be utilized for patients at high risk for distal embolization.

The surgical draping routine is performed according to institutional policy and surgeon preference. The surgical drapes must be positioned to allow access to the patient's groin region for possible exploration of the femoral arteries.

Surgical Intervention[2,20]

1. A midline abdominal incision is made from the xiphoid process to the symphysis pubis. Hemostasis is achieved and the abdominopelvic cavity is explored to confirm the extent of the aneurysm. The cavity is also explored to assess the condition of the organs and to detect any other pathology.
2. The transverse colon and omentum are reflected superiorly. The small intestine and ascending colon are delivered outside of the abdomen to prevent injury and to increase exposure. Warm, moist laparotomy sponges may be used to cover and protect these structures during the surgical intervention. A Lahey (bowel) bag may also be utilized.
3. An abdominal self-retaining retractor is inserted to retract the intestines and to provide exposure for the surgical team. Moist laparotomy sponges should be used to protect the wound edges from the retractor components such as malleable and right-angle blades.

4. The retroperitoneal space is opened by an incision through the posterior parietal peritoneum, beginning at the Ligament of Treitz and carried inferiorly over the bifurcation and beyond the origin of the iliac arteries. Long Metzenbaum scissors and DeBakey forceps are commonly requested.
5. The inferior mesenteric artery is isolated and secured with a vessel loop.
6. The internal and external iliac arteries are exposed to allow vascular clamp placement. If the common iliac artery is aneurysmal, then only the external iliac arteries are mobilized. Atraumatic vascular clamps are used to occlude the iliac artery.
7. The aorta is exposed above the aneurysm utilizing blunt and sharp dissection. The aorta is mobilized up to the level of the renal arteries and exposed to permit the placement of a large right-angle vascular clamp. The ureters are identified and avoided.
8. A knitted Dacron® vascular graft is selected after sizing, and blood is drawn from the vena cava to preclot the graft. Preclotting is not necessary if the surgeon selects a woven polyester or PTFE graft.
9. The patient is given systemic heparin (the optimal dose being 70-100 U/kg of body weight for immediate effect) and the drug is permitted to circulate for three minutes prior to clamping.
10. Vascular clamps are applied to the internal and external iliac arteries bilaterally (or to the common iliac arteries).
11. An aortic clamp, such as a Fogarty, Satinsky, or DeBakey, is applied to the aorta, above the aneurysm.
12. The aneurysm is opened longitudinally along the anterolateral wall by utilizing a scalpel or electrosurgical blade and heavy scissors. Thrombotic and atheromatous material is removed from the interior of the aorta and lumbar vessels are oversewn. The medial sacral and inferior mesenteric arteries may be sutured at this time if not ligated previously.
13. A T-shaped extension is cut into the proximal border of the aneurysm, and the anterior aneurysm wall is opened and irrigated with copious amounts of heparinized saline to flush small thrombus fragments from the wall of the aorta.
14. A prosthetic vascular graft is prepared for insertion. Graft size can be determined by direct measurement or by visual estimate. If the aneurysm does not involve the aortic bifurcation, a straight (tubular) graft is used. In most cases, a bifurcated (Y-shaped) graft will be utilized.
15. The aortic graft is irrigated with heparinized saline solution, and all fibrotic plaque is removed in preparation for anastomosis. Double-armed vascular suture is placed through the aortic cuff and the graft to create the proximal anastomosis.
16. It is imperative to communicate with the anesthesiologist prior to the release of the proximal vascular clamp. A large Fogarty clamp is placed on the proximal portion of the graft, and the proximal aortic clamp is released to test the anastomosis. The two ends of the double-armed vascular suture are tied together, and the proximal anastomosis is completed. Additional vascular sutures may be required if any leaks are observed at the anastomosis. Pledgeted suture may also be utilized to contain leaks at the anastomosis.
17. The distal portion of the aorta is inspected for back bleeding. The right limb of the vascular graft may be flushed with heparinized saline and brought down to the common iliac bifurcation. The right limb of the graft is cut to the correct length.
18. An arteriotomy is performed on the right common iliac vessel, and the graft limb is anastomosed in an end-to-side fashion, using double-armed vascular suture.
19. Prior to completion of the iliac anastomosis, the distal and proximal clamps are opened for flushing. The ends of the suture are tied and circulation is restored.
20. The same process is repeated for the left limb of the vascular graft, and the anastomosis is completed.
21. The anterior wall of the aneurysm sac is sutured over the proximal aortic graft.
22. The abdominal wound is closed in layers, and dressings are applied according to surgeon preference.
23. The surgical instruments and supplies should remain sterile until the patient has been transported to the PACU or SICU.

Potential complications

Unfortunately, a number of complications can occur following AAA repair. Risks associated with AAA repair include injury to the ureters, myocardial infarction, spinal cord ischemia, renal failure, massive hemorrhage, and death.

Mortality ranges from 0%-3% for patients with elective repair to uncomplicated aneurysms to more than 80% for patients with rupture, hypotension, and oliguria.[27] Many patients requiring aortic surgery also have coronary artery disease and are at a greater risk of perioperative myocardial infarction.[10]

Perioperative bleeding can occur due to an uncontrolled vessel, a leaking anastomosis or a coagulopathy. Postoperative hemorrhage can occur in any patient, and hemodynamic instability and evidence of continued blood loss should indicate early abdominal re-exploration.

Acute ischemia of the lower limbs is an additional potential complication following AAA repair. This occurs when emboli or atheromatous debris pass down the arteries in the leg from the site of the AAA repair. Occlusion of the larger iliac and femoral arteries can be treated by embolectomy. If the tiny blood capillaries are affected, this leads to reduced tissue perfusion and may necessitate

amputation. Other less common complications following AAA repair include bowel infarction, impotence, graft infection, spinal cord ischemia, and paralytic ileus.

Summary

An aneurysm is a local dilation of a blood vessel that gradually enlarges and weakens the wall of the blood vessel. As this occurs, the risk of spontaneous rupture increases. The most common form of aneurysm, AAA, is usually asymptomatic and is often discovered during routine physical examination.

The goal of AAA repair is the resection and replacement of the diseased portion of the abdominal aorta with a prosthetic vascular graft. Insertion of the prosthetic vascular graft relieves symptoms, prevents rupture, and restores arterial continuity.

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CE Exams

Preventing Surgical Errors: The Role of the Surgical Technologist

1. **__ involves the commission or omission of an act that a reasonable person would not have committed.**
    a. malpractice
    b. proximate cause
    c. negligence
    d. res ipsa loquitur

2. **__ involves deliberate conduct that violates an individual's scope of practice.**
    a. malpractice
    b. proximate cause
    c. negligence
    d. res ipsa loquitur

3. **Which of the four elements of negligence case must be linked to show proximate cause?**
    a. duty-breach of duty
    b. duty - injury
    c. injury- breach of duty
    d. none of the above

4. **Which doctrine applies in almost every instance in which a foreign body is mistakenly left in the patient?**
    a. malpractice
    b. res ipsa loquitur
    c. proximate cause
    d. all of the above

5. **Which applies if a member of the surgical team operates while under the influence of alcohol?**
    a. malpractice
    b. res ipsa loquitur
    c. proximate cause
    d. none apply

6. **If an STSR performs a task under the supervision of the surgeon, but that task is prohibited by state law, the STSR has committed __.**
    a. malpractice
    b. neglect
    c. breach of duty
    d. no illegal activity was committed

7. **Which statement about counts is NOT correct?**
    a. The circulator and STSR must verify/account for each counted item.
    b. Packaging materials are a viable way of verifying actual quantities.
    c. Needles in suture packs should be verified when opened on the field.
    d. Trash and linens may not be removed after preoperative counts.

8. **Which team member searches for missing items in nonsterile areas?**
    a. STSR
    b. circulator
    c. surgical assistant
    d. everyone on the team

9. **An "X" on the patient's skin means __.**
    a. X marks the spot
    b. Don't operate here
    c. Either A or B
    d. None of the above

10. **Prior to the introduction of any medication or solution onto the surgical field, the STSR and circulator must verify __.**
    a. drug name
    b. dosage/concentration
    c. expiration date
    d. all of the above

A Robot's View of the Prostate

1. **Which of the following risk factors doubles a man's risk of developing prostate cancer?**
   a. age over 65 years
   b. family member with the disease
   c. place of residence
   d. frequent intercourse

2. **Which is not a screening test for prostate cancer?**
   a. DRE
   b. PSA
   c. EPT
   d. None are screening tests

3. **Which is not a preventable risk factor for prostate cancer?**
   a. Area of residence
   b. Diet
   c. Type of employment
   d. age

4. **Which is mismatched?**
   a. Gleason Grade 5: metastasis
   b. Gleason sum 3: low-grade tumor
   c. Gleason sum 6: least aggressive
   d. Gleason sum 9: high-grade tumor

5. **Which is mismatched?**
   a. Stage A: localized tumor
   b. Stage B2: cancer is limited to one side of prostate
   c. Stage C: tumor spread to structures near the prostate
   d. Stage D2: cancer spread to bones

6. **Complications of radical prostate surgery include:**
   a. excessive hemorrhage
   b. incontinence
   c. impotence
   d. all of the above

7. **Robotics provide an advancement over laparoscopic surgery because:**
   a. reduces hand tremor
   b. allows greater degrees of freedom
   c. allows greater flexibility of movement
   d. all of the above

8. **How many ports are needed for this robotic surgery?**
   a. 3
   b. 2
   c. 4
   d. 6

9. **Cauter should not be used near the __.**
   a. areolar tissue and bladder
   b. neurovascular bundle
   c. pedicles
   d. fascia of Zuckerkandl

10. **With robotic surgery, the patient will be hospitalized approximately ___.**
    a. 72 hours
    b. 48 hours
    c. 36 hours
    d. 24 hours

Ovarian Cystectomy and Bilateral Tubal Ligation: A Case Study/Part I

1. **Due to a __, this patient should take antibiotics prophylactically before the surgery.**
   a. peptic ulcer
   b. mitral valve prolapse
   c. anxiety disorder
   d. appendectomy

2. **__ is a combination of erythromycin and sulfisoxazole.**
   a. Ceclor®
   b. Codeine
   c. Alprazolam
   d. Sulfimycin®

3. **__ is a drug which depresses the central nervous system and is used to treat insomnia.**
   a. Ambien®
   b. Alprazolam
   c. Glucotrol®
   d. loratadine

4. **Which result of the Differential Blood Count tests may be related to the patient's asthma?**
   a. basophils
   b. eosinophils
   c. neutrophils
   d. monocytes

5. **Which of these hematology results are mismatched?**
   a. Platelet count-detects clotting disorders
   b. Leukocyte count-detects infection or immune dysfunction
   c. Red blood cell count-detects hypoxia
   d. Erythrocyte count-detects iron containing pigment

6. **Which hematology test evaluates the effect of anticoagulant drugs on the patient?**
   a. Mean corpuscular hemoglobin
   b. Partial thromboplastin Time (PPT)
   c. Prothrombin Time (PT)
   d. International Normalized Ratio (INR)

7. **The Blood Urea Nitrogen (BUN) test measures __.**
   a. creatinine output
   b. adrenal gland function
   c. metabolic waste from kidneys
   d. protein production

8. **__ is a protein that acts as a carrier to maintain blood volume and pressure.**
   a. Albumin
   b. Calcium
   c. Chloride
   d. Creatinine

9. **__ is essential for water balance, muscle and nerve function, and normal metabolism.**
   a. Calcium
   b. Potassium
   c. Sodium
   d. Zinc

10. **Hypoglycemia is a low level of __.**
    a. calcium
    b. carbon dioxide
    c. bilirubin
    d. glucose

Ovarian Cystectomy and Bilateral Tubal Ligation: A Case Study/Part II

1. **Spinal anesthesia was used instead of general because __.**
   a. the patient is diabetic
   b. the patient is asthmatic
   c. the patient wanted to remain awake
   d. all of the above

2. **The spread of anesthetic and duration of action are influenced by:**
   a. volume of agent
   b. concentration of agent
   c. rate of injection
   d. all of the above

3. **Which procedure performed is also called salpingectomy?**
   a. Laparotomy
   b. Oophorocystectomy
   c. Bilateral tubal ligation
   d. Exploratory surgery

4. **Exploratory surgery is recommended if an ovarian mass is greater than __ or does not decrease in size over __.**
   a. 6cm; 3 months
   b. 1 inch; 3 months
   c. 1 inch, 6 months
   d. 6 mm, 6 months

5. **Which is not true about the Pomeroy technique?**
   a. Involves the removal of a section of each tube
   b. Causes minimum tubal destruction
   c. Provides a surgical specimen of each tube
   d. Is considered a temporary method of sterilization

6. **Which of the following diagnostic studies may be influenced by antibiotics?**
   a. HCT
   b. WBC count
   c. Calcium
   d. All of the above

7. **Which can raise glucose levels?**
   a. Antibiotic drugs
   b. Anesthetic agents
   c. Ice chips
   d. None of the above

8. **The loss of blood during surgery does not affect:**
   a. HCT
   b. MCV
   c. WBC
   d. MCHC

9. **Intravenous fluids may affect:**
   a. Calcium
   b. Chloride
   c. BUN
   d. glucose

10. **The antiemetic __ was ordered postoperatively.**
    a. Motrin®
    b. Zofran®
    c. Bupivacaine
    d. Fentanyl

Intracranial Stereotactic Navigation: Cost Analysis and Patient Outcomes Reviewed

1. **The primary criticism of intraoperative MRI is __.**
   a. time
   b. safety
   c. cost
   d. none of the above

2. **The mean scan time in the Bohenski study was __ minutes.**
   a. 6
   b. 12
   c. 16
   d. 20

3. **Deep brain stimulators have become standard treatment for __ patients.**
   a. glioblastoma multiforme
   b. Parkinson's disease
   c. pituitary adenomas
   d. schizophrenia

4. **The average cost of an intraoperative MRI machine (excluding equipment and building costs) is __.**
   a. $1-$1.5 million
   b. $3-$4 million
   c. $100,000 - $150,000
   d. $300,000 - $400,000

5. **Of the 40 patients that underwent an MRI scan, what percentage is accurate and usable?**
   a. 15%
   b. 35%
   c. 65%
   d. 85%

6. **What was the most common postoperative complication associated with stereotactic brain biopsy?**
   a. Infection
   b. Hemorrhage
   c. Embolism
   d. stroke

7. **Which is the least expensive type of stereotactic navigational system?**
   a. framed
   b. intraoperative MRI
   c. frameless
   d. radiosurgery

8. **Neurosurgery for Parkinson's disease most often utilizes __.**
   a. framed system
   b. frameless system
   c. intraoperative MRI
   d. radiosurgery

9. **What is used to replace the frame when a frameless navigation CT scan is performed?**
   a. lasers
   b. probes
   c. fiducials
   d. X-ray beams

10. **Which of the stereotactic systems account for brain shift?**
    a. Framed
    b. Frameless
    c. Intraoperative MRI
    d. None account for brain shift

Gynecologic Surgery Perioperative Considerations, Part I

1. **According to Boyd and Groome, the strongest predictor of postoperative morbidity was?**
   a. experience of the surgeon
   b. attitude of patient toward surgeon
   c. preexisting medical disorder
   d. hospital's asepsis and infection control measures

2. **COPD is caused by:**
   a. asthma
   b. emphysema
   c. pneumonia
   d. tuberculosis

3. **The condition in which the heart valves collapse backward, causing blood to leak back into the atrium is called:**
   a. congestive heart failure
   b. premature ventricular contractions
   c. COPD
   d. mitral valve prolapse

4. **Serum creatinine and BUN studies asses:**
   a. pulmonary function
   b. renal function
   c. capillary refill
   d. hormone levels

5. **Which type of incision runs parallel to abdominal Langer's lines?**
   a. transverse
   b. vertical
   c. oblique
   d. none of the above

6. **Problems associated with the __ incision include increased infection rates, increased blood loss, and possible nerve damage.**
   a. sunrise
   b. paramedian
   c. Pfannenstiel
   d. Rocky-Davis

7. **Which of these incisions provides the most secure wound closure?**
   a. Küstner
   b. Midline
   c. Maylard
   d. Pfannenstiel

8. **Which is not a transverse incision?**
   a. Maylard
   b. Rocky-Davis
   c. Pfannenstiel
   d. Küstner

9. **Which incisions may leave the patient more susceptible to hernia formation?**
   a. Pfannenstiel and Küstner
   b. Midline and paramedian
   c. Maylard and Cherney
   d. Rocky-Davis and gridiron

10. **Radiation therapy can be provided without risk of bowel complication after this type of incision:**
    a. extraperitoneal
    b. transperitoneal
    c. subperitoneal
    d. none of the above

Third- party Reprocessing of Single-use Devices in the Operating Room: A Managerial Perspective

1. **The primary factor driving the trend toward reprocessing SUDs is:**
   a. cost savings
   b. safety
   c. time savings
   d. staff shortages

2. **Which group is the most involved in the regulation of reprocessed single-use devices?**
   a. AHA
   b. FDA
   c. OSHA
   d. CDC

3. **According to a Healthcare Risk Management article, __ believed the reprocessing of SUDs posed a threat to surgical patients.**
   a. 70% of nurses
   b. three of four surgeons
   c. 60% of hospitals
   d. none oppose reprocessing

4. **Third party reprocessors are regulated by __: hospitals are regulated by __.**
   a. OSHA; AHA
   b. FDA; AHA
   c. CDC; OSHA
   d. FDA; OSHA

5. **For an item to be considered for reprocessing, it must be:**
   a. of high quality
   b. costly enough to justify the expense
   c. capable of being cleaned and sterilized
   d. all of the above

6. **Bar codes on reprocessed items do not track:**
   a. hospital name
   b. reprocessing history
   c. patient's name
   d. department within the hospital

7. **The most common SUD reprocessed is:**
   a. sternotomy blades
   b. sequential compression devices
   c. burrs and drill bits
   d. gloves

8. **A benefit of a reprocessing program is:**
   a. biohazard waste reduction
   b. cost savings
   c. funding for new initiatives (equipment, etc)
   d. all are benefits

9. **The most significant issue in evaluating a reuse program is:**
   a. patient safety
   b. cost savings
   c. hospital efficiency
   d. funding for new initiatives (equipment, etc)

10. **Which of the following is an important issue that must be taken into consideration when reprocessing SUDs?**
    a. cross contamination
    b. performance issues
    c. legal/ethical issues
    d. all of the above

Chronic Regional Pain Syndrome: The Facts with a Patient's Perspective

1. **CRPS is more common in:**
   a. men
   b. women
   c. children
   d. the elderly

2. **Which is mismatched?**
   a. Type I; cases with no known nerve injury
   b. Type I: reflex sympathetic dystrophy
   c. Type I: distinct major nerve injury
   d. Type II: causalgia

3. **Which clinical feature is considered the hallmark of CRPS?**
   a. pain
   b. swelling
   c. stiffness of joints
   d. muscle spasms

4. **Which is false about symptoms of CRPS?**
   a. Joints become stiff and muscles can atrophy.
   b. Burning pain and localized swelling occurs at the site of injury.
   c. Pain is unaffected by emotional distress or stress.
   d. Rashes may appear on the extremities.

5. **Extreme sensitivity to touch is called:**
   a. causalgia
   b. paroxysmal pain
   c. allodynia
   d. hyperalgesia

6. **Which is not a type of spread in CRPS?**
   a. independent
   b. malignant
   c. continuity
   d. mirror image

7. **A TENS unit may be used for:**
   a. muscle stimulation
   b. biofeedback
   c. muscle strengthening
   d. desensitization

8. **Which is not considered a treatment option for CRPS patients?**
   a. occupational therapy
   b. physical therapy
   c. casting and immobilization
   d. pain psychology

9. **Which of the following is the method for measuring the heat emission of a limb?**
   a. Doppler studies
   b. sympathetic nerve blocks
   c. thermograms
   d. spinal cord stimulators

10. **Which type of block may affect the recurrent laryngeal nerve?**
    a. stellate ganglion block
    b. lumbar sympathetic block
    c. epidural block
    d. limbic block

Surgery of the Head and Neck: Thyroid and Laryngeal Procedures

1. **Who was the first surgeon to describe thyroidectomy in 1873?**
   a. Theodor Billroth
   b. Theodor Kocher
   c. Silas Weir Mitchell
   d. Pierre Joseph Desault

2. **Which structure may have to be elevated or transected to perform a tracheotomy?**
   a. recurrent laryngeal nerve
   b. thyroid isthmus
   c. parathyroid gland
   d. hyoid

3. **Radiation to the head and neck in childhood increases the risk of:**
   a. goiter
   b. hyperthyroidism
   c. thyroid cancer
   d. none of the above

4. **For thyroidectomy and parathyroidectomy, the patient is placed in which position?**
   a. Supine
   b. Fowler's
   c. Reverse Trendelenburg
   d. Right lateral

5. **After which surgery should the patient's head be elevated to 30˚ to minimize bleeding?**
   a. supraglottic laryngectomy
   b. total laryngectomy
   c. parathyroidectomy
   d. hemilaryngectomy

6. **Which is not a risk factor for laryngeal cancer?**
   a. asbestos exposure
   b. tobacco usage
   c. vocal training
   d. alcohol use

7. **Before a supraglottic laryngectomy patient is discharged, he or she must:**
   a. be able to defecate
   b. be taught to eat
   c. learn to vomit
   d. none of the above

8. **Which is left intact after hemilaryngectomy?**
   a. cricoid cartilage
   b. one vocal cord
   c. hyoid bone
   d. all of the above

9. **Patients for this surgery must sign a consent form for total laryngectomy:**
   a. hemilaryngectomy
   b. supraglottic laryngectomy
   c. total laryngectomy
   d. all of the above

10. **Which is not a complication of total laryngectomy?**
    a. drain failure
    b. pharyngocutaneous fistula
    c. stomal stenosis
    d. all are complications

Abdominal Aortic Aneurysm Resection

1. **AAAs are usually:**
   a. Not detected until rupture occurs
   b. Not detected during physical examination
   c. Symptomatic and detected upon examination
   d. Detected during diagnostic testing for other conditions

2. **Fusiform aneurysms:**
   a. Balloon out to one side
   b. Occur after a tear of the inner arterial wall
   c. Enlarge circumferentially in a spindle shape
   d. Occur at the proximal and distal portions of the artery

3. **False aneurysms (pseudoaneurysms) are a/an:**
   a. True aneurysm
   b. Dissecting aneurysm
   c. Contained hematoma
   d. Dilation of arterial wall layers

4. **Which of the following symptoms indicate an AAA rupture?**
   a. Hypertension
   b. Severe headache
   c. Shortness of breath
   d. Vascular insufficiency

5. **Surgical repair of an AAA is recommended if the aneurysm is:**
   a. 2 cm
   b. 3 cm
   c. 4 cm
   d. 5 cm

6. **Morality ranges from __ following elective AAA procedures.**
   a. 0% - 3%
   b. 4% - 7%
   c. 8% - 11 %
   d. 12% - 15%

7. **Risk factors associated with AAA development include all of the following except:**
   a. Immunocompromise
   b. Coronary artery disease
   c. Uncontrolled hypertension
   d. High blood cholesterol level

8. **In an end-to-side, the graft is anastomosed to the:**
   a. Renal artery
   b. External iliac vessel
   c. Inferior mesenteric artery
   d. Right common iliac vessel

9. **The retroperitoneal space is opened beginning at the__.**
   a. Splenic flexure
   b. Hepatic flexure
   c. Xiphoid process
   d. Ligament of Treitz

10. **Which of the following clamps would be appropriate to use when clamping the aorta?**
    a. Allen
    b. Doyen
    c. Dennis
    d. Fogarty

Answers CE CREDIT PKG 1A: 21 CONTINUING EDUCATION CREDITS

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Preventing Surgical Errors: the Role of the Surgical Technologist

a b c d	a b c d		
1. □ □ □ □	7. □ □ □ □		Mark one box next to each number. Only one correct or best answer will be selected for each question.
2. □ □ □ □	8. □ □ □ □		
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A Robot's View of the Prostate

a b c d	a b c d		
1. □ □ □ □	7. □ □ □ □		Mark one box next to each number. Only one correct or best answer will be selected for each question.
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Ovarian Cystectomy and Bilateral Tubal Ligation: A Case Study/Part I

a b c d	a b c d		
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Ovarian Cystectomy and Bilateral Tubal Ligation: A Case Study/Part II

a b c d	a b c d		
1. □ □ □ □	7. □ □ □ □		Mark one box next to each number. Only one correct or best answer will be selected for each question.
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Intracranial Stereotactic Navigation: Cost Analysis and Patient Outcomes Reviewed

a b c d	a b c d		
1. □ □ □ □	7. □ □ □ □		Mark one box next to each number. Only one correct or best answer will be selected for each question.
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Gynecologic Surgery Perioperative Considerations, Part I

a b c d	a b c d			
1. □ □ □ □	7. □ □ □ □			Mark one box next to each number. Only one correct or best answer will be selected for each question.
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Third-party Reprocessing of Single-use Devices in the Operating Room: A Managerial Perspective

a b c d	a b c d			
1. □ □ □ □	7.□ □ □ □			Mark one box next to each number. Only one correct or best answer will be selected for each question.
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Chronic Regional Pain Syndrome: The Facts with a Patient's Perspective

a b c d	a b c d		
1. □ □ □ □	7. □ □ □ □		Mark one box next to each number. Only one correct or best answer will be selected for each question.
2. □ □ □ □	8. □ □ □ □		
3. □ □ □ □	9. □ □ □ □		
4. □ □ □ □	10. □ □ □ □		
5. □ □ □ □			
6. □ □ □ □			

Surgery of the Head and Neck: Thyroid and Laryngeal Procedures

a b c d	a b c d			
1. □ □ □ □	7. □ □ □ □			Mark one box next to each number. Only one correct or best answer will be selected for each question.
2. □ □ □ □	8. □ □ □ □			
3. □ □ □ □	9. □ □ □ □			
4. □ □ □ □	10. □ □ □ □			
5. □ □ □ □				
6. □ □ □ □				

Abdominal Aortic Aneurysm Resection

a b c d	a b c d				
1. □ □ □ □	7. □ □ □ □				Mark one box next to each number. Only one correct or best answer will be selected for each question.
2. □ □ □ □	8. □ □ □ □				
3. □ □ □ □	9. □ □ □ □				
4. □ □ □ □	10. □ □ □ □				
5. □ □ □ □					
6. □ □ □ □					