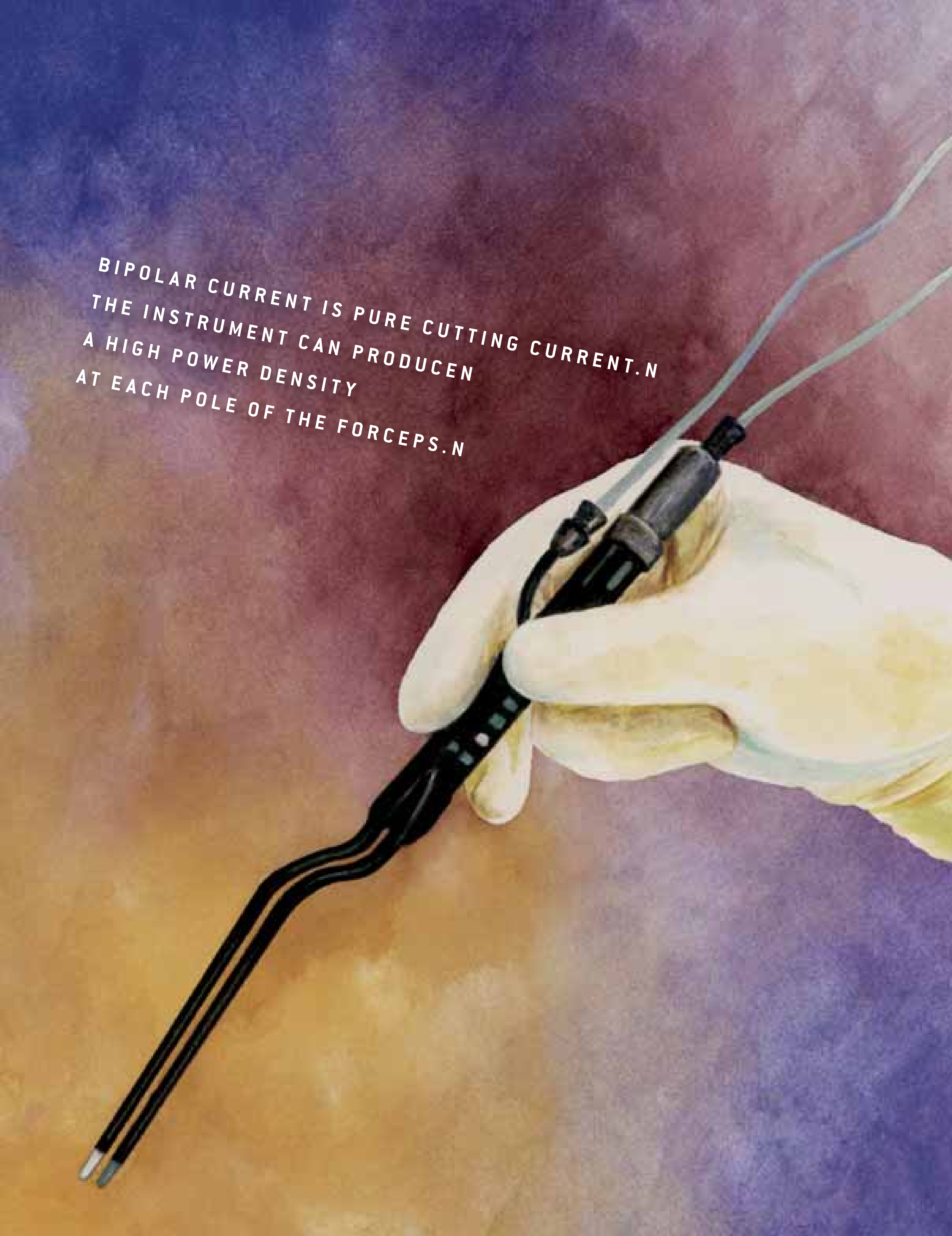

BIPOLAR CURRENT IS PURE CUTTING CURRENT.N
THE INSTRUMENT CAN PRODUCEN
A HIGH POWER DENSITY
AT EACH POLE OF THE FORCEPS.N

ElectrosurgeryN

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Common language usage in the operating room uses the term electrocautery as an umbrella term for all-electrical instruments and procedures. This is incorrect and will be clarified in this article. A proper understanding will assist with safe, effective, and efficient usage.

Basic terminology

The following definitions are necessary to a basic understanding of electrosurgery:

- *Blend:* a term that indicates that the electrical current is interrupted between 20-50% of the time.
- *Current:* the passage of a given amount of electrons through a conductor over a specified period of time (measured in amperes).
- *Electrical power:* watts = volts x current.
- *Electricity:* the movement of electrons between two poles that are charged, one positive and one negative.
- *Electron:* a particle of positive or negative energy that creates heat as it passes through human tissue.
- *Impedance:* the resistance to the flow of electrons to a given conductor.
- *Joules:* the total energy consumed or given off over a specified period of time.
- *Resistance:* difficulty passing a current through a given conductor (measured in ohms).
- *Sparking:* the result of an electrical current flowing through a gas.
- *Voltage:* the force required to push electrons through a given the substance (eg human tissue).

A conceptual distinction

A distinction needs to be made between two terms that are typically used interchangeably in the operating room. *Electrocautery* refers to the use of a direct electrical current to heat metal. The hot metal is then applied to a tissue, which is cauterized. This is a technique that is no longer employed in the operating room. *Electrosurgery* refers to the manipulation of the electrons through living tissue, using an alternating current that can cause heat build up in the cell and thereby destroy the cell. A *generator* is the machine that creates an alternating current at a frequency that does not stimulate muscle activity (500,00-3 million cycles per second). An *alternating current* is one that flows in one direction and then the other. The current flow increases to a maximum in one direction, which produces a positive peak and then flows backward to the alternate maximum or negative peak. This current produces what is called a "sinusoid" wave. This type of current can be manipulated in such a way that it has different effects upon tissue. The wave type has a positive and negative peak. A measurement to from the positive peak to the negative peak is called *peak-to-peak voltage.*

In order to perform electrosurgery, the alternating current must be manipulated. A wave form that is simple, sinusoidal, undamped (unmodulated), is produced by a continuous energy supply. This current is the cutting current used in electrosurgery. The cutting current does not require a peak voltage as high as the coagulating waveform.

One advantage of the coagulation current is that the electrons are pushed through in short bursts. A cooling effect between the electrical bursts allows coagulation to take place. Most of the generators today provide a *blended current,* which is a result of combining the cutting and coagulation currents. The blended waveform interrupts the current at variable intervals. The effect is to have periods of cutting current and periods of coagulating current.

Monopolar/bipolar

Modern electrosurgery uses monopolar and bipolar techniques. When using the *monopolar* technique, current travels through an active electrode and is received at another neutral plate (ground plate) after it passes through the body. In this case, the body serves as the conductor.

Since the current is disbursed over both plates, it is of relative low intensity. Heat is generated, because the plates are of dramatically different sizes. The active electrode is small and capable of creating a current of a sufficient density to cause a burn at the point where the electrons enter the body. Even though the ground plate is larger, burns may be produced at the exit point also.

Because the potential for unwanted burns is high, the surgeon should use the lowest setting to accomplish any given task. The surgical team must guarantee that the dispersive electrode is making good contact with the patient and is large enough to prohibit a build up in the current density.

Generators

Generators are required to produce the current. Those used for surgical purposes can produce about 8,000 volts when they are in the coagulation mode; however, normal usage occurs in the 1,000–3,000 volt range. The generators in current usage are relatively safe. They offer what is called an *isolated ground circuitry system,* which reduces the chances that the current will seek an alternate path to the ground. The most common system used in the operating room employs disposable return electrodes known as "ground pads." There is a built-in monitor at the generator that will sound an alarm if an imbalance registers between the two pads or points of contact. The operating room team should remember that the returning electrode must be oriented so that each of the two pads is an equal distance from the operating site.

Bipolar electrosurgery

A *bipolar* system incorporates an afferent and efferent electrode into an instrument that has two poles. This eliminates the need for a grounding pad. Bipolar current is pure cutting current. The instrument can produce a high power density at each pole of the forceps. This permits a small amount of tissue desiccation, confined to the shape and size of the forceps at the point it is in direct contact with the tissue. This system eliminates the chance of alternate pathways for the current to flow through. This is a clear advantage over the monopolar system.

That said, there are some drawbacks and restrictions on the use of the bipolar system. With bipolar use, the impedance load is several times that of monopolar use. This means that there is much less output for any given setting when using the bipolar technique. Bipolar technique, therefore, is generally restricted to situations in which small portions of tissue are being desiccated.

In gynecologic surgery, one must be aware that instruments used in laparoscopy and for the purposes of sterilization can differ in both design and the ability to desiccate tissue. The manufacturer's guidelines should be followed precisely. These guidelines should be known by both the CST in the scrub role and the surgical assistant.

Safety

Safety principles during electrosurgery should be followed without exception, since the surgeon is often focused elsewhere, the surgical technologist and surgical first assistant should monitor the safe usage of electrosurgical instruments.

Surgical technologists should already know basic principles of safety, but select reminders are:

- All the electrode pencils should be in a safety holster when not in use.
- A monitored return electrode system should be used.
- Use the lowest voltage that will create the desired effect.
- Place the return electrodes as close to the operative site as possible.
- Inspect the instrument and cord insulation prior to each use.
- Be aware of the extra length of laparoscopic instruments and make appropriate adjustments.

Uses

Electrosurgery may be used to vaporize tissue (cut), desiccate tissue (coagulate), and fulgurate tissue (coagulate superficially). When the coagulation waveform is in use, the current sparks to tissue without a cutting effect, because the heat is widely dispersed and the heating effect is intermittent. The water inside of the cells is heated and the cells dehydrate slowly. The term *coagulation* is generally used to include both desiccation and fulguration. Technically, this is incorrect usage and the two can be compared and contrasted in several different ways:

- Fulguration always produces necrosis anywhere the sparks land.
- Desiccation may or may not produce necrosis.
- Fulguration is more efficient at producing surface-level necrosis.
- Desiccation is more efficient at producing a deep tissue reaction.
- Fulguration requires about 20% of the current flow required for desiccation.

Factors affecting coagulation

Some factors that affect the amount of coagulation verses cutting current include:

- The faster an electrode is moved over or through tissue, the greater the cutting effect.
- The broader the electrode, the greater the coagulation defect.
- If the tissue is touched with the electrode prior to keying the generator, more lateral charring will result.

When a cutting effect is desired, a high electrical current is delivered via a fine electrode. This generates intense intracellular heat and causes the intracellular water to boil and vaporize the cell. Vaporization dissipates some of the heat. This cooling effect prevents thermal spread to adjacent tissues. The reduction and spread is not limited to the lateral direction but includes the depth of penetration and, therefore, may prohibit any deep coagulation effect. In order to increase the vaporizing effect of the cutting waveform, the electrode should be activated prior to touching the tissue to be cut. Four technical points are worth mentioning at this time:

- Unless the surgeon has extensive experience, skin incisions are best made with a normal surgical scalpel.
- When working in fatty tissue, one should change to a flat blade and coagulation waveform in order to perform a cutting function.
- Any time that tissue is grasped with a forceps, either the cutting or coagulation waveform produces desiccation of tissue.
- When attempting to coagulate surface vessels in a bloody field, irrigation with nonelectrolyte solutions improves the efficiency and effectiveness.

Argon beam coagulator

The argon beam coagulator is a relatively recent method of achieving coagulation. A monopolar electrode is used in conjunction with a beam of argon gas that passes through the cannula at rate of 12 L/min, when used during a laparotomy, and at 4 L/min, when used in conjunction with laparoscopy. Argon gas has certain ionization properties that enhance the distance a spark can travel to complete an electrical circuit. The beam that is produced by the argon is bright with a bluish tint that makes it easy to see and to aim at a bleeding surface. The CST should be familiar with the manufacturers' guidelines for the specific machines used in their institutions.

Lasers

Laser stands for Light Amplification by the Stimulated Emission of Radiation. Light is produced when energy is applied to an atom and changes an electron to a higher level of instability. The electron will return to its stable state by releasing a photon of light. This type of light is called *incoherent light* and has many different wave settings, directions, and phases.

When energy is applied to a laser medium, the electrons are changed into an unstable energy level. These electrons spontaneously decay to a lower energy level but one that is higher than its normal international level. This new state is relatively long-lived and stable. Enough energy can be pumped into the laser medium so that the population of atoms is produced which are mostly of this higher energy state. Whenever an electron spontaneously returns to its normal state, a photon is emitted. The photon is of the same wavelength. The photon travels down the long axis of the optical cavity and continues to stimulate at the same wavelength. The photons reach the mirrored ends of the optical cavity and are reversed. They continue to be able to stimulate the further release of photons. Laser radiation is produced as energy is applied to the laser medium. There are four classes of lasers:

1. Low powered or high-powered, embedded lasers
2. (A) Visible lasers (400-700 nm). Under normal circumstances, these do not present a hazard to vision, but if viewed directly for extended periods, the light could cause damage to the eye.
   (B) Visible lasers that are not intended for viewing and, under normal operating conditions, do not produce an injury to the eye (if viewed directly and for less than 1,000 seconds).
3. (A) Lasers that would not cause injury to the eye if momentarily viewed.
   (B) Lasers that present a hazard if viewed directly. This includes Intrabeam and specular reflections.
4. These lasers present a hazard from direct, specular, and diffuse reflections. They may also produce skin burns and be a fire hazard.

Lasers are commonly identified by their active medium. Excimer gas lasers are either argon or xenon. Excimer lasers include nitrogen, helium-cadmium, argon, krypton, xenon, helium-neon, and hydrogen fluoride. Metal vapor lasers include copper vapor, gold vapor, neodymium-YAG, erbium, holmium-YAG, holmium-YLF, and chromium sapphire as the active medium. Dye lasers use rhodamine, and semiconductor lasers use gallium arsenide. Of course, most of these are not used in the surgical setting.

For controlling and focusing the beam, there are two delivery mechanisms available. The first is a micromanipulator. This is a joystick that is used to move a mirror that is placed distal to the focusing lens. This type of manipulator is commonly found on the colposcope and the operative microscope. In the second system, the focusing lens is located in the handpiece.

Accidents

Because of the potential danger presented by the laser, every hospital has a laser committee and a person appointed as laser safety officer. Everyone should be aware of the guidelines established for the various lasers. Causes of laser accidents are listed below in order of frequency:

- Incorrect alignment procedure (almost 30%)
- Incorrect eye wear
- Voltage too high
- Eye protection not used
- Equipment malfunction
- Improper service
- Accidental exposure

Indications and frequency

As with most new technology, the indications for laser usage continue to expand. At this time, some indications for the use of laser in gynecologic surgery are:

- Cervical cone
- Condylomata
- VIN
- VAIN
- Adhesiolysis
- Endometrial ablation
- Salpingostomy
- Myomectomy

The relative frequency of laser procedures is as follows:

- Excision of endometriosis
- Lysis of adhesions
- Ovarian cystectomy
- Uterosacral ligament procedures
- Presacral neurectomy
- Salpingo-oophorectomy
- Ectopic pregnancy
- Myomectomy
- Laparoscopic assisted vaginal hysterectomy
- Retropubic urethropexy
- Sacral colpopexy

CUSA

The Cavitron Ultrasonic Surgical Aspirator (CUSA) is a surgical device that affects tissue in three ways: viscous stress, heating, and cavitation. Viscous stress occurs secondary to an interaction between intracellular water and the vibration of bubbles, which are at the micron size. This causes vibration and, if a critical point of shear stress is induced, a breakdown in the cell with attendant hemolysis occurs.

The CUSA is an acoustic vibrator. It converts electrical energy into mechanical motion. The handpiece contains an electric coil that is wrapped around a nickel alloy magnetostrictive transducer. This transmits an alternating electrical field to an alternating magnetic field, causing contractions and expansion in the transducer. This fluctuation pulses the hollow, cone-shaped, titanium tip. The standard size has an inner diameter of 2 mm, however, a microtip is also available. Laparoscopic versions are also available today.

Both irrigation and aspiration features are built into the handpiece. Cellular debris can be removed from the operative site with ease. The greatest advantage to using the CUSA is that cancerous tissue can be broken down easier than healthy tissue. This makes the CUSA an appropriate device for debulking pelvic tumors.

Conclusion

Electrosurgery, laser surgery and the Cavitron Ultrasonic Aspirator are just a few of the recently developed resources that enable surgeons to function more efficiently and facilitate the patient's recovery. More applications for these technologies are undergoing research and, undoubtedly, new benefits will be available in the future.

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.