Chapter 8: Electrosurgery

QUICK POINTS

• The purpose of an electrosurgery device (ESU) is to give a physician the ability to cut and/or coagulate tissue, using high frequency currents.
• The physician has 3 modes of operation depending upon the needs of the surgery. The modes include cut mode, which cleanly cuts tissue by vaporizing it, coag (coagulation) mode, which cauterizes tissue to stop bleeding and blend mode, which offers various combinations of cut and coag modes.
• Alerts include audible distinctive tones for cut, coagulation (coag) and blend modes, visual alerts showing the mode in use and a return electrode monitor (REM) to prevent skin burns.
• Common issues the biomed will experience with electrosurgery unit are foot-switch problems, REM issues and ECG interference.
• Specific to the electrosurgery unit, the biomed ensures power output accuracy in all modes of operation, REM operation, related alarm operation and RF electrical safety.
• Electrosurgical generators are found in operation rooms (OR), outpatient clinics (OP) and emergency departments (ER).
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ELECTROSURGICAL CHALLENGE QUESTIONS

1) What is the purpose of an electrosurgery unit?
2) What are the 3 modes of operation of an ESU unit and explain how each work.
3) What is the difference between monopolar and bipolar?
4) How does the REM alarm work?
5) How does the cut/coag safety work?
6) Why is RF leakage measured during a PM?
7) What is the most common issue resulting in no output of the ESU?
8) How can the user reduce ESU induced noise in the patient’s ECG?
9) Outline the specific tests a biomed performs on an electrosurgery unit during a PM.
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**HOW IT WORKS**

A physician uses an electrosurgery unit for two main purposes which are cutting and/or coagulation of a patient’s tissue. This is accomplished by passing high frequency oscillating currents through the patient's tissue between two electrodes. This oscillation varies between approximately 300kHz to 3MHz with power levels that vary between zero to 400 watts. By varying the output waveform’s duty cycle, the electrosurgery device produces a signal that will cut, coagulate or do a combination of both, referred to as blend mode. Cut mode vaporizes tissue and mimics a surgeon using a sharp knife to cut tissue. Coagulation mode changes the tissue from a liquid to a solid producing a clot at the site. Blend mode offers the surgeon a combination of both cutting and coagulating the tissue at the same time. There are two modes used to describe the current path which are monopolar and bipolar. In monopolar mode, current flows between the surgical site and a return electrode plate placed on the patient’s back, hip or leg. In bipolar mode, current flows at the surgical site only. The surgeon initiates operation by pressing a button on the hand-piece or by using a foot-switch. The switch is usually color coded yellow for cut/blend modes and blue for coag mode.
Cut mode

Pure cut is used for dissection (remove moisture from) only. In cut mode the *duty cycle* is at 100%. When using cut mode, the surgeon vaporizes the tissue due to the rapid heat produced. In pure cut mode, the ESU performs like a stainless steel scalpel, in that the surgeon has little or no control over bleeding.

Coagulation mode

In coagulation mode the duty cycle is 30% or less and at a higher voltage, when compared to cut mode. This mode produces much less heat when compared to cut mode which results in a coagulation of the tissue. Coagulation means *changing from a liquid to a solid*. A surgeon uses the electrosurgery unit’s coagulation mode to stop or limit blood
loss by producing a coagulum or clot at the surgery site. There are two types of coagulation: Coagulation (also known as pinpoint) and Fulguration (also referred to as spray). Pinpoint coagulation is used to stop local bleeding. Fulguration is non-contact coagulation by which current jumps from the active electrode to the tissue. Fulguration is used for sealing off small hidden bleeders which surgeons have difficulty locating and is also useful for those areas with large bleeders.

**Blend mode**

In blend mode the duty cycle is varied between approximately 30% to 99%. Manufacturers may refer to this mode of operation as hemostasis or blend mode. As the physician varies the blend mode they can obtain a combination of cut and coagulation to varying degrees. A blended cut is ideal for sealing off small bleeders when cutting through soft tissue.
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Cut mode vs. Blend mode vs. Coag mode

The physician has the option of using two configurations of the active and return electrodes. These options are either monopolar and bipolar.

**Monopolar mode**

In monopolar mode the current flows between the electrode at the surgical site and a return electrode. The return electrode is usually placed on the patient’s back, leg or hip. The return electrode may also be described as the dispersive electrode, patient plate or grounding plate. Current flow occurs between the monopolar hand-piece and the return electrode. The purpose of the return electrode is to allow a safe path of current from the patient. Resistance between the patient’s skin and return electrode must be kept to a low value. A return electrode has a large surface area and is placed as close as possible to the surgical site. A high contact resistance between the return electrode and patient, can damage (burn) the skin at the return electrode sight. To avoid skin damage, electrosurgery units have an alarm called the *return electrode monitor* (REM). This circuit will check for a low contact resistance between the patient’s skin and
the return electrode. The electrosurgery unit will allow the physician to apply the output when the resistance is below a certain value which is about 150 Ohms or less.

**REM Electrode**

**Bipolar mode**

In bipolar operation current flows between two points on the hand-piece which requires a specially designed forcep. Another specially designed electrode uses current that jumps or sparks on the patient’s tissue, referred to as a fulguration hand-piece. Bipolar electrosurgery does not require a patient plate. This method of electrosurgery is usually used to coagulate tissue or vessels between the two electrodes of the hand-piece.
USER SETUP (monopolar)

1. The user attaches the return electrode to the patient prepping the skin to ensure good adhesion and therefor low contact resistance.
2. The user turns the unit on and may run some self-tests as per the manufacturer’s recommendations prior to use.
3. The user may setup a surgical smoke evacuation device used during the procedure. Studies show that the smoke created during electrosurgical usage can be very toxic.
4. The user may connect a foot-switch or hand-switch as required for the procedure.
5. The physician will then select the desired mode of operation (cut/blend/coag) and selects the desired power setting.
6. The physician will use either a hand-switch or foot-switch to activate the output.

Typical hand-switch and foot-switch
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HOW TO TEST/PM AN ELECTROSURGERY UNIT

A PM should be performed after every repair and on a routine scheduled based upon the manufacturer’s recommendations or the local authority. There are specific electrosurgical unit testing devices that are required to check its accuracy. Listed below are generic electrosurgery tests intended as a guide only. Always refer to the manufacturer’s service manual for a complete recommended PM guideline.

Perform a visual inspection:
- A visual inspection of the electrosurgical unit may show the biomed physical problems to correct, during the PM.

Verify all user controls are operation:
- Ensure all user controls are functional. A biomed will often find user controls not working during their testing.
- If a button or user control is not working, repair it prior to placing the electrosurgery unit back into service.

Review error logs:
- Always check the error logs or codes if available. Many electrosurgical units offer error codes that can be used to determine what failure has occurred either at the time of use or during prior uses.
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Output power checks:
- An electrosurgical analyzer is used to load the electrosurgical unit and then measure the output power and current. The biomed checks multiple levels available to the user for accuracy at the recommended test load. Always check the manufacturer’s guidelines for acceptable accuracy at specific loads.
- Ensure that all modes are tested including cut, coag and the various levels of blend.
- Always ensure the manufacture’s recommended testing procedure is followed so the device is not damaged during testing.

REM monitor checks:
- The analyzer usually offers a REM testing ability which allows the biomed to vary the resistance of the REM circuit monitor to ensure the REM circuit alarms at the proper trip point. The biomed connects the return electrode to the analyzer to perform this test. The REM circuitry should have high and low operating points that trip the REM alarm and prevents output.
- Ensure that when the REM alarm is activated, output from the ESU is terminated. Always refer to the manufacture’s manual to obtain the pass/fail criteria.

Checking the output waveform:
- Some manufacturer’s may recommend measuring the output waveform as part of the performance testing. Checking the output waveform may show the biomed issues with the ESU. This may be
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performed using an oscilloscope or the ESU testing device which may have this ability.

Cut/Coag safety check:
- This safety circuit ensures that the cutting operation does not function when both switches are depressed at the same time. If the physician accidentally presses both foot-switches (or hand-switches), coagulation mode is enabled since it is the least destructive mode. Ensure coag mode is enabled if both switches are depressed.

Ensure the ESU is electrically safe:
- Measure the ground resistance.
- Measure the chassis leakage.
- Measure the applied parts leakage.

ESU high frequency leakage test:
- This test is for an isolated electrosurgical unit ONLY. There are three common tests available based upon IEC standards. Always refer to your local regulations standards for the HF leakage tests required for your area. Excessive RF leakage from the electrosurgery unit can cause shocks to the users. These shocks are usually not dangerous to the patient or personnel but can create a hazard during surgery. A spark created, as a result of excessive RF leakage, may cause the user to twitch, or the spark may ignite flammable gases used during surgery.
- Measure the high frequency leakage (isolated units only) and ensure they are below the acceptable levels.
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Ensure your documentation is accurate:

- All repairs and performance tests need to be documented and filed so they can be retrieved at any time.
- This documentation should include all parts used for repair and all the above test results showing the equipment is within manufacturer’s and local authorities acceptable limits.
- These documents may be used to validate proper maintenance was performed by the biomed. Ensure all documentation is accurate!

What to do if any tests fail:

- If any device maintained by the biomed fails a functional test and/or electrical safety, it is the biomed’s responsibility to pull it out of service!
- Failure means a patient safety issue exists!
- Fix the issue prior to placing the ESU back into service!
QUICK SERVICE TIPS

Patient skin burns:
- REM safety circuits used in monopolar operation, are specifically designed to limit patient skin burns from occurring. They will inhibit output of the electrosurgery unit if the contact resistance of the return electrode is higher than the manufacturer’s design, usually about 150 Ohms or more. The users must not touch the patient or allow any devices to touch the patient when the ESU’s output is active. This may allow current to flow through the user or device to ground which may cause burns at that site. Patient monitor inputs must be isolated or could be damaged during surgery. If the biomed encounters a patient burn issue, they must immediately remove the electrosurgery unit from operation. They should then work with the users involved in the procedure to determine how the alternate path of current occurred, which caused the skin burn. Once the issue is found, corrective action must occur immediately, so the issue does not occur again.

REM issues:
- A user may complain about the electrosurgery unit inhibiting operation due to REM alarm. The biomed must first ensure the REM is working according to manufacturer’s specifications by varying the resistance between the REM connectors. The REM circuitry should have high and low operating points that trip the REM alarm and prevents output. If the REM circuit alarms according to manufacturer’s
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Specifications, the probable cause is poor return electrode contact with the patient’s skin. This is usually caused by poor skin preparation prior to placing the return electrode on the patient. The issue may also be the result of a faulty return electrode pad.

Use can’t get an output:

- If the physician is using the foot-switch to operate the electrosurgery unit, the foot-switch itself may be the issue? It is constantly moved, kicked, run-over, solutions are commonly spilled on it, etc. If the user can’t get an electrosurgical output or it cuts-out while in use, look for wire breaks and/or faulty switches within the foot-switch. A quick fix would be to swap out the foot-switch with a known working foot-switch. It is also not uncommon for the reusable hand switch to become faulty causing the issue. Again, swapping out the hand-switch is a quick way to determine the issue.

ECG interference:

- Often a patient is connected to a patient monitor while using an ESU. The RF noise from the ESU may be the issue. To reduce this ESU noise:
  1. place the return electrode as close as possible to the operative sight.
  2. place the ECG electrodes as far as possible from the operative sight and ensure good skin preparation.
  3. select a lead view that selects active electrodes located the “same” distance to the operative sight.
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**CHALLENGE ANSWERS**

1) The purpose of an electrosurgery unit is to give a physician the ability to cut and/or coagulate tissue, using high frequency currents.

2) The 3 modes are:
   - **Cut Mode**: cuts like a sharp knife by vaporizing or dissection of tissue due to high heat generated. It works with a 100% duty cycle and offers no control over bleeding.
   - **Coag Mode**: stops or reduces bleeding by using less heat causing a coagulation of tissue. It works with 30% duty cycle or less
   - **Blend Mode**: offers a combination of cut and coag modes. It works with 30 to 99% duty cycle. A blended cut is ideal for sealing off small bleeders when cutting through soft tissue.

3) The difference between monopolar and bipolar is:
   - **Monopolar**: current flows between the electrode and the return electrode.
   - **Bipolar**: current flows between 2 points of a hand-piece.

4) The REM alarm works by ensuring a low contact resistance between the patient and REM plate or it will terminate the ESU’s output. About 150 Ohms or less.

5) The cut/coag safety circuit works by ensuring coag mode is enabled, if both switches are pressed at the same time.

6) RF leakage is measured during a PM to ensure it is low, since it may produce sparks which may cause the user to twitch during surgery or the spark may ignite flammable gases.
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7) The most common issue causing no output of the ESU is a faulty foot-switch or hand-switch?

8) The user can reduce ESU induced noise in the patient’s ECG by
   a. Placing the return electrode as close as possible to the operative sight.
   b. Place the ECG electrodes as far as possible from the operative sight and ensure good skin preparation.
   c. Selecting a lead view that selects active electrodes located the same distance to the operative sight.

9) The specific tests a biomed performs on an electrosurgery unit during a P&M include:
   • Verify output power accuracy
   • Verify all modes are working
   • Verify REM safety circuit is working
   • Check the output waveform
   • Verify the Cut/Coag safety is working
   • Verify the ESU high frequency leakage is safe