# ENDOSCOPY

**Terms you will become familiar with in this module**

| | |
|---|---|
| endoscopy | side-viewing duodenoscope |
| fibre optic endoscope | video endoscope |
| charged coupled device | angulation |
| insertion tube | torque |
| bending section | lumen |
| light guide plug | cold illumination |
| distal tip | occlusion |
| degraded image | button caps |
| O-rings | gastroscope |
| colonoscope | cholangio pancreatography |
| angiography | ampulla of Vater |
| hepato-biliary system | papilla |
| invasive surgery | puritis |
| iris | sphincterotomy |
| stent | biliary tree |
| cystic duct | common bile duct |
| cannula | sphincteretome |
| contrast medium | retrograde injection |
| diathermy | patient plate |
| adipose tissue | ground lead |

## INTRODUCTION

Increasing reliance on remotely operated microvideo and electronic equipment [**endoscopy**] has reduced the invasiveness of exploratory surgery, the risk and the recovery time. Combined with the more common use of ultrasonic and laser technology, equipment reliability demands have increased the need for immediate technical support and expertise.

The use of the **endoscope**, a tube through which video, electronic and mechanical equipment can be directed to an internal site, has become a significant development for many technicians and necessary specialisation is increasingly common.


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## Activities

Identify the type and number of scopes used in your medical centre.
Arrange to observe an ERCP procedure. Make notes of the room set-up.

## Questions

What types and brands of **duodenoscopes** are in use?
What equipment is necessary to operate each scope that is not common to all of them?
Where are they kept and are they stored adequately?

## Mechanical construction of endoscope

Both **fibre optic** and **video endoscopes** use the same basic design principles and, to a large extent, the same mechanical construction. The main difference between the two endoscopes is the system which transmits the image – the fibre optic endoscope utilises bundles of optical fibres and the video-image endoscope uses advanced charged coupled device technology [CCD].

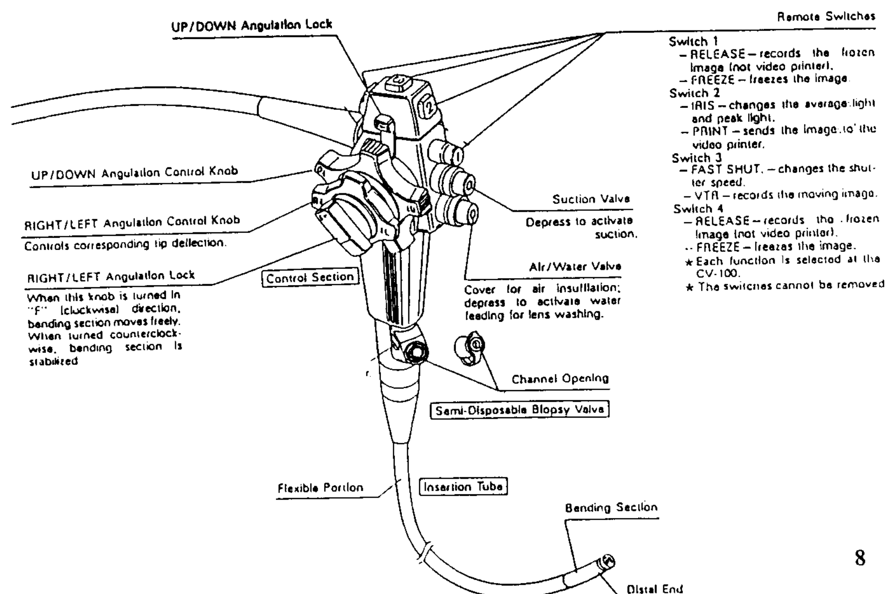


fig 1 The endoscope


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The mechanical construction of both fiberscopes and videoscopes can be broken down into three categories:

1. The **control body** houses the **angulation mechanism** that translates rotational movement from the angulation control knob to linear motion in the angulation wires. It also contains the complex optical system in the eyepiece of the fiberscope or, alternatively, the electronic remote control functions of the videoscope. The air/water and suction valves are also located on the control body.

2. The **insertion tube** is composed of several layers, the first of which is the outer sheath. This comprises a complex plastic covered tube with a coating to reduce friction. It is also very flexible and designed to protect the patient from trauma, and the endoscope from fluid ingress.

The next layer is a metal braid to provide strength and durability. Underneath is another layer, consisting of a metal spiral for added strength and to make the instrument responsive to **torque** [twisting]. This also protects the delicate internal image and light guide bundles from compression and kinking in use. The materials and construction are varied to give the differing insertion characteristics, essential for safe and successful endoscopy.

At the end of the insertion tube is the **bending section** which is made up of several segments, hand riveted to give a high degree of flexibility. Rotational movement of the control knobs causes deflection of the bending section and, therefore, changes the direction, in which the instrument 'looks' or 'moves'.

The complete assembly is very strong, as it is necessary to protect the internal components listed below from damage during use.

- Image guide fibre bundle or CCD unit
- Biopsy channel
- Air channel
- Water channel
- Four angulation wires
- Light guide fibre bundle

Because these internal components are closely packed within the **lumen** [internal space] of the insertion tube, a dry lubricant is used to reduce possible friction damage as they move against one another.

3. The **light guide connecting tube** is composed of three layers, the external plastic sheath for flexibility and fluid proofing, the metal braid for strength and durability, and an internal steel coil sheath for added strength and kink resistance. At the end of the light guide connecting tube is the **light guide plug** probe where the light guide fibre bundle terminates. Between the end of the light guide fibre bundle and the very tip is an infra-red filter, which protects the bundle from heat produced by the light source. The light guide plug also incorporates the connections for the air/water bottle, suction tubing, leakage tester and diathermy safety cord [see fig 1].


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## Light sources for endoscopes

The basic function of any light source for flexible endoscopy is to provide a source of light for subject illumination and video, plus integral facilities for providing lens rinsing, water and air. The illumination is usually produced by a high intensity xenon or halogen lamp, positioned so the light is focused on the tip of the light guide plug probe. An infra-red filter is positioned between the lamp and light guide plug probe to reduce the heating effect from the intense light, producing **cold illumination** at the **distal tip** of the endoscope. A photosensitive feedback system within the video camera or videoscope continuously measures the light intensity of the illumination, and the **iris** contained within the light source automatically adjusts light intensity to give subject illumination for all situations.

## Trouble shooting with light sources

Most light sources allow for variation of the intensity of light transmitted through the endoscope.

Problems experienced in gaining adequate visualisation and light intensity are often due to the control body of the scope not being firmly fixed into the light source.

Another frequently occurring problem occurs when the electrical supply to the light source becomes accidentally disconnected. When it is reconnected,the light source button must be depressed again to achieve optimal light. This problem can be minimised by making sure that cables cannot be accidentally disconnected.

Olympus and Pentax systems use different technologies to initiate the video-image. As a result, they produce a different light quality so that the resulting pictures tend to look quite different in their quality.

Olympus and Pentax scopes require a different cable system to connect them to the Video processor. If a department has both types of scope in operation, simple errors in connecting the leads can result in inadequate, or absence of, color, light or picture. Sometimes due to frequent manipulation of these cables, they can break or dislodge, or simply become 'temperamental'. In these cases, a better set up should be discussed to improve reliability and reduce costs involved in repair and time loss.

Because each scope type requires its own light source and video processing unit, it is important to become familiar with the set ups used at your medical Centre/s, and the operation of each.

A copy of the instrumentation panel attached to the trolley that houses the unit, with the normal position of each function clearly highlighted, is a useful way of reducing time losses when simple resetting problems arise during operation.


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**Activity**

Develop a chart showing the normal settings for an endoscopy light source. Produce the chart at a size and in appropriate colours for easy use on the unit.
After consultation with clinical staff who are experienced with the endoscopy equipment under clinical conditions, write a set of briefing notes which:

- identify probable causes of common problems and;
- explain how to correct the problems which do not require your technical expertise and;
- describe the resetting procedures.

## Lens cleaning

A micropump within the light source provides a constant supply of pressurised air through the light source mouthpiece. When a light guide plug is positioned in the mouthpiece, the air flow is connected. By occluding the air/fluid piston, the air is made to pass down the internal air channel of the endoscope, emerging through the air/fluid outlet nozzle at the distal tip.

When the air/fluid piston is depressed, air entering the water bottle forces water up the fluid channel of the endoscope to wash the objective lens clear of debris. When the lens is not cleaned properly, image quality is reduced [**degraded**]. It should be the first thing checked if complaints about image quality are received.

Frequently the **button caps** become stuck in one position, and do not depress or release easily. As a semi disposable item, the **O-rings** are sometimes worn, but most of the time they only require the application of a suitable lubricant to free them up.

As video-endoscopes become more common, the problem of ensuring that the video-pins are protected from fluid ingress during the cleaning and disinfecting process increases. Protective caps are supplied with the endoscopes and it is a good idea to attach them to the endoscope, with fishing line, to ensure that they are not lost or accidentally forgotten. Expensive and unnecessary damage can occur if they are not properly placed.

## Storage

Storage of endoscopes is another area from which expensive and unnecessary repairs can originate. If you suspect damage is occurring to endoscopes from the manner in which they are stored, check with the person responsible for their care in the department. It is wise to have a written report of problems, and the name of the person identifying and reporting the problem so that a record can be established of the incident which resulted in the problem.

## Record keeping


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A consolidated record of technical problem reports can help to identify common problems and isolate specific equipment items which require frequent attention. Consolidated records are useful for establishing recommendations for replacement, for buying new equipment and for developing routine maintenance schedules. They are also useful for providing informed advice about training needs in the use of specific equipment items.

**Activity**

Develop a technical problem report which can be used by clinical and technical staff to establish consolidated records of equipment performance, cost and maintenance frequency.

**Questions**

What are the most frequent components of the scopes used in your Medical Centre that have been repaired in the last 12 months?
Do any of the scopes in your care have a different maintenance pattern from that published by the supplier?


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## CASE STUDY

Equipment which is ***emphasised,*** **referred to or used** in this case study includes:

- *endoscope*
- **fibreoptic endoscope**
- **video endoscope**
- *side-viewing duodenoscope*
- **gastroscope**
- **colonoscope**
- *light sources*
- **generator Unit**
- *patient plate*
- *diathermy leads*
- **stents**
- *active lead*
- *ground lead*
- **scope cable**
- sphincterotome
- **needleknife**

Mrs Kalantzis phoned her general practitioner at 4 am on Friday morning complaining of terrible pains in her stomach and difficulty breathing. Taken to the medical centre by her husband, she told how she had suffered acute bileous attacks for over twelve months whenever she ate fatty foods. The registrar suggested that she was probably suffering from gallstones. She then injected a mix of pain killer with muscle relaxant and suggested that Mrs Kalantzis should have an examination using an **endoscope** when the latest acute attack had passed. This diagnosis was later confirmed and Mrs Kalantzis was booked into the medical centre for **Endoscopic Retrograde Cholangio Pancreatography** [**ERCP**].

**Activity**

Using your reference sources, identify the main functions of the liver.
Establish how gallstones are formed and where they are most likely to be found.
In discussion with nursing and medical staff, discover the main reasons for performing an ERCP.


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Endoscopic retrograde cholangiopancreatography (ERCP) is a method for directly observing the channels from the gall bladder, liver and pancreas [biliary and pancreatic ducts] by means of a side-viewing **duodenoscope** and an x-ray machine without having to use surgery.

Since the 1960s, endoscopy has been an accepted technique for diagnosing problems of the liver, gall bladder and pancreas [**hepato-biliary system**]. As with Mrs Kalantzis, the client scheduled for an ERCP may have presented with a range of symptoms suggestive of problems in the pancreatic or biliary ducts, including unexplained abdominal pain, jaundice (yellow tinge to skin), itchiness (puritis).

The procedure involves passing a flexible fibreoptic tube [**endoscope**] down the throat, through the stomach and into the duodenum where it is used to locate the **ampulla of Vater** [see fig 3]. A fluorescent dye [**contrast medium] is then injected** into it against the flow of bile and pancreatic juices [**retrograde**]. Radiographs are taken to visualise the common bile [cholangio] and pancreatic ducts [cholangio pancreato-graphy].

In the process of direct retrograde contrast visualisation, the ducts seen entering the duodenum are injected with contrast medium so that they can be observed directly against a non-fluorescent background [**contrast**] using x-ray imaging.

Once the x-ray contrast dye is injected into the bile ducts, it is essential that it can drain back out freely from the ducts, or they can become infected. As a result, some patients not only require diagnosis of their problem but also immediate treatment.

These procedures are performed both as elective and emergency investigations. However, because of the risk of biliary or pancreatic blockage preventing immediate drainage [see fig 2], therapeutic developments such as **sphincterotomy** and **stenting** [placing a 'rigid' tube to maintain a pathway] have become more important than purely diagnostic observations.


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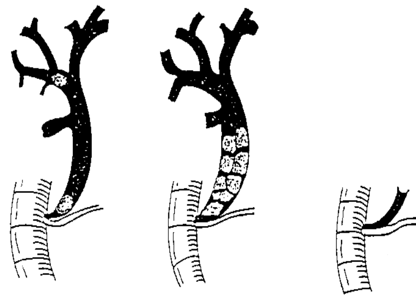
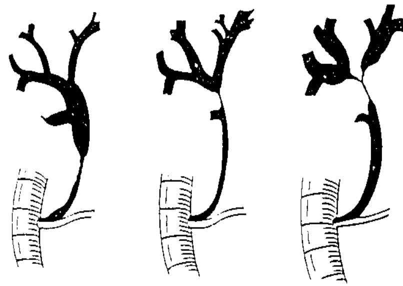


Calculi [gallstones]in the common bile duct



Carcinoma of the bile ducts

fig 2 common blockage types requiring immediate drainage

## ANATOMY AND PHYSIOLOGY

In the **biliary tree**, the **cystic duct** drains bile from the gall bladder, while the **common hepatic duct** provides the route for bile drained from the liver [see fig 3]. These ducts join to form the **common bile duct** which, in turn, extends through the **pancreas** and into the wall of the duodenum. In most people, the distal intramural portion of the common bile duct joins with the pancreatic duct forming one channel in the **ampulla of Vater**. The ampulla [container] empties into the duodenum at the **papilla of Vater** which is located on the **posteromedial** duodenal wall and is classified as the major papilla [raised area].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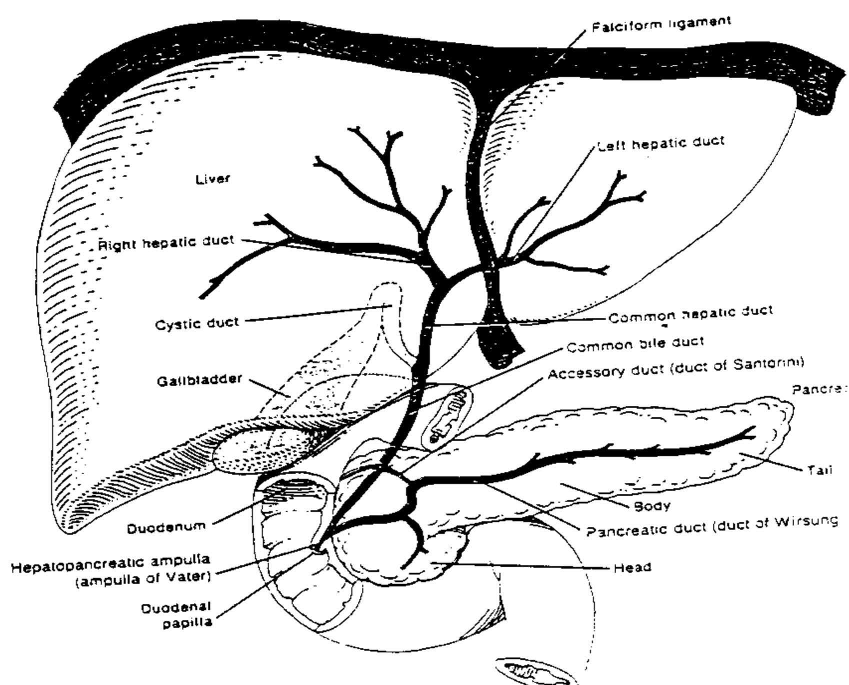


fig 3 The liver and hepato-pancreatic system

The duodenoscope does not enter the biliary or pancreatic ducts directly. It is the instrument that acts as the 'eyes' for placing small tubes [catheters] into the ducts so that the x-ray dye [contrast] can be injected to enable an x-ray image or hardcopy film to 'see' the outline of the ducts [see fig 2]. The x-ray image is used to make the diagnosis or guide any furtherintervention.

Achieving access to the biliary or pancreatic ducts is dependent on the patient's anatomy. It can take varying amounts of time and equipment. Once the required duct is **cannulated** [the catheter is inserted] then it is possible to exchange equipment over a long guide wire, for another piece of equipment.

In this way it is possible to;

- Enlarge the **ampulla**, to allow for **stent** insertion or **stone extraction**.
- Remove stones from the biliary tree
- Place a plastic or metallic stent in the ducts to facilitate bile drainage, in the case of ducts obstructed due to cancer.

Take specimens for laboratory analysis, to aid in clinical diagnosis.

ERCP is one of the major diagnostic and therapeutic procedures for biliary tract and pancreatic disease. . These procedures are performed under X-ray


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guidance and usually involve a skilled endoscopist, radiology or gastroenterology nurses, a radiographer, an anaesthetist and a biomedical engineering technician. A large range of technical equipment is necessary to achieve an ERCP, and often needs to be set up prior to each case or session as often a dedicated facility does not exist, and a room has to be borrowed in the X-ray department.

## Endoscopes

A **duodenoscope** differs from a **gastroscope** or **colonoscope** in its design, to facilitate instrumentation of the **ampulla**, and biliary or pancreatic ducts. This is performed with side-viewing instruments, called duodenoscopes which allow face-on views of the **papilla**, which cannot be achieved with standard forward-viewing endoscopes. The duodenoscope is also longer.

[There is little practical difference between the duodenoscopes of different companies, so physician preference and cost determine the instrumentation utilised in each facility. All have wide-angle lenses to facilitate orientation and a **working channel** of at least 2.8mm]. Endoscopes with larger working channels (of at least 3.8-4.2mm) are needed for **stenting**, and can be used for all ERCP procedures, except those in children. Most departments will have more than one scope, and may even have different types of scopes. As in other areas **video-endoscopes** are supplanting **fibreoptic duodenoscopes**.

## Procedure

Mrs Kalantzis has been diagnosed as probably suffering from gallstones. She has been scheduled to enter hospital on Monday evening for an ERCP on Tuesday morning. She is not allowed to eat or drink for 8 hours prior to the procedure so that her stomach and duodenum will be reasonably empty and the examination will not be complicated by recently eaten food. Shortly before the procedure, she will be given medication (sedation & analgesia) to facilitate a comfortable examination.

Taken to an x-ray room which has been modified for the endoscopy, Mrs Kalantzis is positioned on her right side, and a mouth guard is placed in her mouth to prevent damage to her teeth by the casing of the endoscope. Her blood pressure, oxygen saturation and heart are monitored throughout the procedure.

The duodenoscope is introduced through Mrs Kalantzis's mouth and down through the stomach into the second part of her duodenum. The **ampulla of vater** is located and seems to be inflamed. Catheterisation of the ampulla is performed under direct viewing and contrast medium is injected through small catheters inserted separately into the pancreatic and common bile ducts. The progress of the dye is followed by the radiographer and the endoscopist using a video screen. It quickly becomes clear that Mrs Kalantzis has a number of small gall stones blocking the common bile duct [see fig 1].


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These will have to be removed immediately or the dye will not be able to drain.

As the procedure begins, the light source fails. It is realised that the power source has become disconnected but, after reconnection, it is still not bright. A rapid reading of the checklist on the side of the unit shows that the light source button has to be depressed to sharpen the aperture. The procedure continues in the makeshift conditions of the x-ray room.

**X-Ray facilities**

Diagnostic ERCP is a radiographic procedure initiated by an endoscopist. It is essential to have optimal X-Ray equipment and rapid film processing. Some endoscopy units are fortunate enough to have their own radiology facilities. Those who have to borrow a room in the X-ray department recognise the need to modify the layout to create optimum operating conditions. Most endoscopists use standard fluoroscopy or a barium suite but modern digital C arm units provide excellent screening quality and have hard-copy capacity. [see fig 4]

There must be enough room for the endoscopist, radiographer, and nurse assistants (and all of their equipment). Most X-ray tables are installed close to one wall. If the patient is put on the table in the standard position for a barium examination, the endoscopist and those assisting are cramped into a corner. It is usually better to work with the patient's position reversed. As a result, the endoscopist and radiographer are on the same side of the table, and both can see the fluoroscopy, and video monitor placed across from them [see fig 5].

In the modified x-ray room, the patient position is reversed so that the radiographer and endoscopist work side by side. They and the assisting nursing staff can easily see both the video and fluoroscopy screens. There needs to be adequate room at the head of the patient for patient airway management and the 1st nurse assistant.


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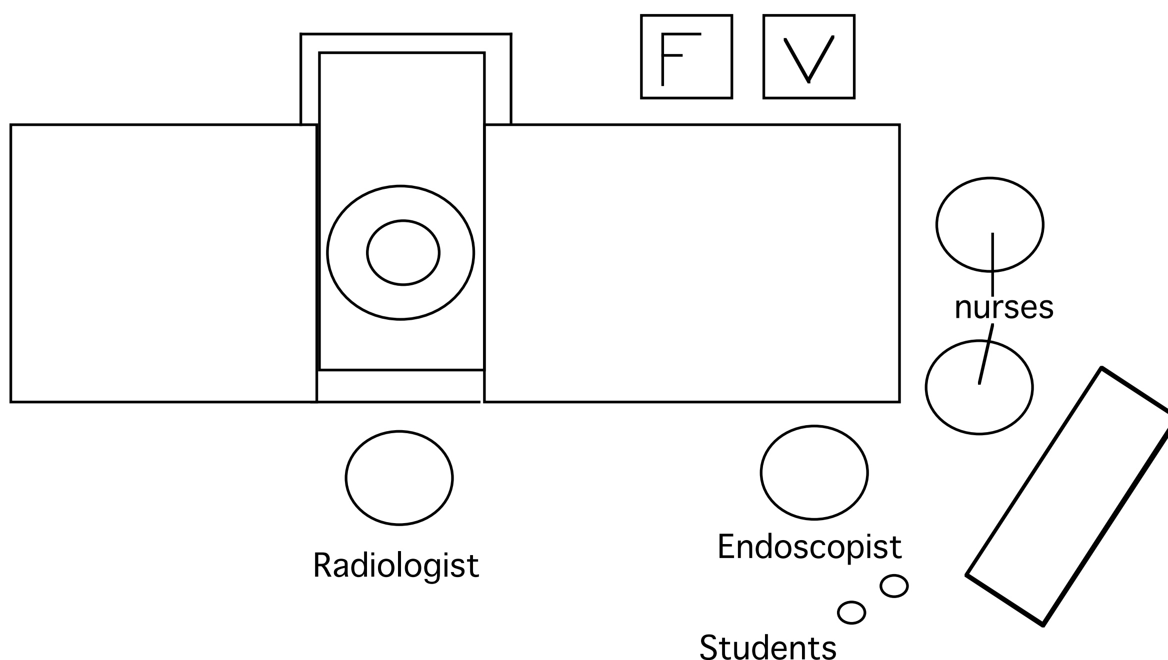


fig 5. Endoscopy in a modified x-ray room

When working in this position it is important to check that the tabletop can travel far enough so that the patient's upper abdomen can be brought into fluoroscopic view; and the X-ray image can be reversed. The table should be capable of tilting at least 30 degrees up and down.

As a BMET responsible for the maintenance of ERCP equipment, you will be familiar with the uses of the equipment you are being asked to maintain or repair, but the way the equipment is actually positioned and used may be a source of problems which could be avoided with some discussion between the health care team.

Because few departments have a dedicated area for endoscopic procedures, they are often inadequate in some way, and equipment is subjected to wear and tear, or damage through room design. For example multiple cables are often lying on the floor due to inadequate power points, subjecting them to potential damage.

The shape and the positioning of the gallstones make it difficult for the endoscopist to remove the stones from Mrs Kalantzis's bile duct through the ampulla so it is decided to enlarge the ampulla by performing a **sphincterotomy.**

## Diathermy

In order to perform the wide range of therapeutic procedures, it is often necessary to enlarge the ampulla, to allow the use of larger items of equipment or facilitate the removal of stones, or insertion of stents. This is termed a **sphincterotomy** and is performed with the standard side-viewing duodenoscopes, appropriate **sphincterotomes** and an electrosurgical source [**diathermy**]. Most diathermy equipment allows the application of blended coagulation and cutting currents.


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## Activities

The microsurgical use of diathermy equipment during endoscopic procedures makes regular maintenance of electrosurgery equipment and attachments absolutely essential.
The expert role of the BMET in understanding and communicating the exact use, application, and safety of the equipment utilised for diathermy is very important, especially if units are changed or upgraded. All members of the health care team must be familiar with the characteristics of the equipment they are using.

Develop a policy for the introduction of new diathermy equipment into your medical centre. Who must know that the new equipment is available?
Who must be trained in the use of the equipment?

Develop a checklist for the routine checking of the equipment before it is used by: the technicians, the nursing staff, the medical staff.
Should the equipment be checked after it is used?
Who should be responsible for checking diathermy equipment?
Who should be responsible for reporting incidents occuring during the use of diathermy equipment?

## Patient Safety during diathermy

To ensure that the patient is not harmed during the use of diathermy, the health care team must ensure that no other alternative pathway exists for the electrical current to pass through. The patient must not be in contact with any metallic surfaces or objects. The **patient plate** must be properly positioned. Equipment should be in good repair with no damaged cables or leads.

It is important that the connections between the diathermy **ground lead** and the scope are checked frequently to ensure a good connection and patient safety.

If the **ground electrode** lead is damaged, or the **patient plate** is not properly in contact with the patient's skin, the current will find the path of least resistance [**ground source**]. This path of least resistance is an alternative return pathway for the current to take. Alternative pathways may be anywhere where metal is accidentally in contact with the patient's skin. This can be through the ECG electrodes on the patient's chest, or the table, resulting in a burn where the alternative high current density is located.

## Patient Plate

A malleable disposable patient plate is used. This type of plate is made of foil and is usually rectangular in shape. The are self-adhesive and padded. Care should be taken to ensure that the plate makes contact with the patient's skin over the whole of its surface area. Bony prominences and hairy areas are avoided, because uneven contact between the patient plate and the


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patient's skin can occur. A muscle area such as the patient's thigh is an ideal site, as it forms a good conductor; fatty areas are avoided, as fat is a poor conductor. Skin folds and scar areas are also avoided. The patient's skin should be clean and thoroughly dry before application of the plate. To prevent moving the plate, it should be applied after the patient is positioned.

The most common factors which result in a patient burn are:

*Incorrect electrode application site*

Causing poor electrical contact due to placement on areas such as scar tissue, excessive fatty [**adipose**] tissue, excessive hair.

*Reduction of electrode contact area*

May be caused by patient repositioning or movement, moisture invasion or gel drying during lengthy procedures,.

### Alternative Pathways for Current Transmission

The usual course for current to flow is out of the **active electrode**, through the patient to the return [**ground**] electrode. If there is a problem or fault with any of the diathermy equipment, such as the patient plate is not properly in contact with the patient's skin, or the ground electrode wire is broken, then the current will find another ground source or path of least resistance.

### Footswitch

A diathermy unit operated by a footswitch, rather than a hand operated unit is preferable so that the operator's hands are free to manipulate the instrumentation. The footswitch is positioned only for the operator's use. It must be carefully positioned to prevent accidentally standing on it. As an added safety measure, the active lead should not be connected to equipment until the operator is ready to use the diathermy. It should be disconnected immediately after use. It can be reconnected again if it is required.

### Dial Selection

The intensity or strength of the current required, which is controlled by setting dials on the machine is dependent on the operator's preference and technique. There are many electrosurgical [diathermy] generators available commercially. Typically, a generator will be provided with two knobs that regulate power output, one for the coagulation waveform and one for cutting. These are calibrated with arbitrary numbers. A given number setting on one machine usually has no relation whatsoever to the same number setting on a machine of different manufacture. Furthermore, the increase in power output from one setting to the next is not precisely linear. For example, if the dials are provided with settings form 1 to 10, advancement


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to the next higher setting does not necessarily provide a 10% increase in power. In practical terms, the endoscopist must be thoroughly familiar with the characteristics of the electrosurgical generator in use.

Once the **sphincterotome** is placed deeply into Mrs Kalantzis's bile duct and the indication for sphincterotomy is confirmed, the operating team check that the electrosurgical equipment is properly connected while the endscopist and the radiologist check the anatomical constraints on the procedure. The size of the papilla, the size of any stone and the shape of the distal bile duct, can all determine the appropriate and safe length of the incision. It is decided to leave the guidewire though the sphincterotome during the incision. This adds stability and prevents the embarrassment of falling out completely at a crucial moment. The endoscopist reports her concern that there can sometimes be current leakage between the standard guidewire and the diathermy wire so she checks the diathermy settings again before she places the foot pedal carefully, links the active lead and begins the procedure.

Electrical settings vary with electrosurgical machines and the preferences of the expert. The effectiveness and safety of sphincterotomy depend much more on the length of wire in contact with tissue (the current density) than the precise settings. The commonest error is to have too much wire inside the papilla (partially for fear of falling out), and to apply too much bowing tension. Nothing happens when current is first applied (or only slow coagulation will result) which increases the risk of subsequent pancreatitis. There is then a temptation to increase the current settings and pressure, which will eventually and suddenly cut through the coagulated area at alarming speed with a risk of significant bleeding. If nothing appears to be happening when current is applied during sphincterotomy, it is much better to reduce the length of wire in contact with the **mucosa**, which increases the current density and should initiate the incision.

**Activities**

Identify the type of diathermy unit utilised in the area that performs ERCP in your medical centre

**Questions**

What, if anything, indicates to staff that there is a problem with the application of diathermy?
What safety mechanisms should be in place to prevent the patient sustaining a burn from the inadequate use of diathermy?

The enlargement of the ampulla is completed without incident and Mrs Kalantzis's gallstones are removed successfully. She is returned to recovery and released on the following day after careful instruction about her future diet.

**Activity**


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Establish whether ERCPs are performed in a dedicated area, in theatre, or in the X-Ray department of your medical centre.
Observe the procedure and note any parts of the setup things that are less than ideal [sub-optimal] from the point of view of
the positioning and movement of the medical team
the patient's safety
yourself as the technician expected to maintain the equipment

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