CHAPTER 1
HISTORY OF LAPAROSCOPIC CHOLECYSTECTOMY

The history of laparoscopic Cholecystectomy is very colorful moving from skepticism to enthusiasm. It is the enthusiasm, interest, inquisitiveness, intellect of the surgeons and physicians of the earlier days to view the internal organs through open orifices and small holes, thus giving optimal diagnosis and treatment with better cosmesis and little pain, which has surrounded us by an armamentarium of highly specialized and sophisticated equipment and instrumentation like the 3-chip camera high-definition television, and robotic surgery.

We will just take you through a journey of these inventions.

- 1978 - Frimbdberg attempted the first laparoscopic cholecystectomy in pigs.

- 1985-Filipi, Mall Roose tried it in a living patient, but the procedure was abandoned because of inadequate exposure.

- 1985 - Erich Muhe tried to perform laparoscopic cholecystectomy using a Galloscope.

- Frustration developed among the assistants asthey could not see what the surgeon was operating and hence, they could not assist in a meaningful way.

- Articulated attachment was then introduced, which satisfied the assistants and the nurses to some extent. But, the resolution of the image was not good, as the image was split using the articulated attachment.

- By1984,palm-size solid- state cameras were available for use in endoscopic surgery. The introduction of the charged- coupled- device (CCD) image sensors was the pivotal moment in the modern era of endoscopic videosystems.

- 1986 - Miniature solid-state camera was introduced and this was a major breakthrough in the imaging system as the image could be electronically transmitted to the T.V, thus giving a good resolution, more so, the surgeon, the assistant, nurse and all others could view the surgery and assist in a more meaningful way.

- 1987 - Philippe Mouret performed the first laparoscopic cholecystectomy in a patient witha diseased GB.

- Francois Dubois joined Philippe Mouret and after a few animal experiments they went on to perform a series of laparoscopic cholecystectomies.

- 1988 Barry Mc Kernan from Switzerland and William Saye a gynecologist from the United States also performed laparoscopic cholecystectomy.

- Reddick and Olsen also followed suit.

- Eddie and Douglas from Nashville used KTP Laser to perform laparoscopic cholecystectomy. This was published in the Laser medicine and surgery news. Hundreds of surgeons drove down to Nashville to see them use lasers for performing laparoscopic cholecystectomies. But it was soon found that lasers were not without complications and it was not economical too. So, they then continued to perform laparoscopic cholecystectomy using diathermy.

Dr. T. Udwadia from Mumbai performed the 1st Laparoscopic cholecystectomy in India.

References:

1. Dubois F, Icard P, Berthelot G, et al. Coelioscopiccholecys tectomy:preliminaryreportof36cases.*Ann Surg.* 1990;211:60 –62.

2. Cuscheri A, Berci G, McSherry CK.Laparoscopic cholecys- tectomy. *Am J Surg.*1990;159:273.

CHAPTER 2

BASIC PRINCIPLES AND TECHNIQUES OF LAPAROSCOPIC CHOLECYSTECTOMY

The safe performance of Laparoscopic Cholecystectomy demands that certain basic principles are to be observed meticulously.

While adopting a new technique "The Principle of learning to walk before one can run" must be kept in mind.

Laparoscopic (minimally invasive) surgery is the fastest growing specialty in the last decade. Like Laparoscopy, no other technique has gained so much popularity, development and has advanced in short period in all surgical specialties and super-specialties. To make the procedure safer and to avoid complications, morbidity and mortality proper indications and selection of cases and appropriate surgery should be planned. The procedure should be explained to the patient and relatives and proper consent for Laparoscopic / open surgical procedure should be taken.

1. For Laparoscopic procedure, the operating roommust be of adequate size, because after keeping the equipment trolley and two instrument trolleys there must be comfortable movement by the staff. It must be fitted with all necessary electrical connections preferably through voltage stabilizer or UPS for better performance of the equipment.

2. Before starting the procedure and putting the patient on the operating table the adjustability and movements of the table i.e., head up & head down tilt, as well as lateral tilt and lithotomy must be checked. Preferably there should be a radiolucent table-top.

3. All equipment and instruments must be well maintained and in working order, should be checked before starting each procedure. Surgeon himself or trained nurse must have basic knowledge of maintenance and troubleshooting during procedure if instrument fails, and should clean the instruments themselves for better life of instruments.

4. Preferably equipment trolley must be made with 5-6 shelves to accommodate all equipment i.e., T.V. Monitor, CCD Camera unit, VCR, lightsource, CO_2 insufflator, suction-irrigation unit. This way it occupies less floor space in the operating room.

5. Open surgery set should be kept ready on a separate trolley so in case of an emergency, conversion to open surgery is easily done without losing much time.

6. Any surgical procedure is a team -work but laparoscopic procedure is more demanding for teamwork. There must be a regular team (for better co- ordination and good results) includes – Assistant Surgeons, O.T. Nurse, Circulating nurse and technician. All should have a complete knowledge of laparoscopic principles and instruments.

7. In the near future a time may come when it will be possible to perform almost any surgical procedure by minimally invasive surgery but it is mandatory that a surgeon must be well trained for open surgery as well.

8. Bladder and bowel must be empty for good visibility and to avoid injury to structures. For pelvic surgery catheterization and upper abdominal surgery N. G. tube should be passed to keep urinary bladder and stomach empty respectively. For upper abdominal surgery if patient has passed urine before coming to operating room, then catheterization is not necessary.

9. Laxatives given the previous night or giving enema may help specially in pelvic surgery.

10. To avoid slipping of the patient in presence of excess tilt, strapping of patient to the table will help.

11. Most convenient position of the patient is supine but lithotomy may be necessary depending upon operation being performed and surgeon's preference.

12. Some surgeons prefer to regularly apply crepe bandages to the legs to avoid D.V.T.

13. There are various positions for surgeons to stand while performing procedures, it is surgeon's preference but surgeon should stand diagonally opposite the organ to be operated and telescope / camera operator may stand side by side.

The basic rule is that the surgeon, the field being operated upon andthe monitor should be approximately in a straight line.
For pelvic surgery right-handed surgeon usually stands on left side and left-handed surgeon on the right side.
For upper abdominal surgery some surgeons regularly use extended lithotomy position and stand in between the thighs of the patient and monitor is kept at the head end of the table.
Depending on procedure a second assistant may stand on opposite side and another T.V. monitor may help for better vision.

14. General anesthesia with endotracheal intubation and controlled positive pressure ventilation is a must for most of the laparoscopic procedures so that there will be good relaxation. Some procedures can be done under epidural or local anesthesia.

15. Before starting the procedure, all connections are made and checked. Gas and suction-irrigation tubes, camera, light-source and diathermy cables. Two diathermy cables may be required depending upon "Male" or "Female" connection on the instruments. Bipolar diathermy is safer than monopolar diathermy. To cover the camera cable a sterile plastic cover or cloth sheath can be used.

16. Heparinized solution can be kept in a tray for keeping the used instruments so that blood clots will not block and damage theinstruments.

17. Before making initial entry head low tilt position should be made. Incision is usually made at the umbilicus. It maybe:

- Infraumbilical.

- Supraumbilical.

- Trans-umbilical.

Infra-umbilical incision is most commonly used and less risk of injury to great vessels.

Supra-umbilical incision- the advantage is that needle and trocar being automatically directed towards the defect in Linea alba at umbilicus but, there is risk of injury to great vessels.

Trans-umbilical vertical incision allows easy entry and gives a good cosmetic result.

There are two methods for initial entry:

I. Open method – (Hasson)
Little larger 2-2.5cms incision is made through all layers, introduction of Veress needle is not required for pneumoperitoneum and special blunt trocar is used. A purse-string suture is applied through all the layers and tied over the cannula. Some surgeons regularly prefer this technique to the blind technique (closed method).

Advantages:
Avoids risk of injury to viscera and vessels in difficult cases and in presence of adhesions.

Disadvantages**:**
- Larger incision is required.

- More time is required for initial entry or if there isgas leak during surgery.

- Gas leak and surgical emphysema, if peritoneum is not included in the purse-string suture.

- In suspected adhesions in the lower abdomen, first entry can be through left upper abdomen.

II. Closed method

About 1-1.5cm skin and subcutaneous deep incision is made (Linea alba or rectus sheath should not be incised) and through this Veress needle for pneumoperitoneum and primary trocar are inserted.

After the incision the abdominal wall below the umbilicus is lifted in the mid line by the surgeon or on both sides by surgeon and assistant. Abdominal swab may be used for proper grip. This gives little safety i.e. umbilicus is lifted up from the great vessels.

The Veress needle must be checked for its patency before inserting. The Veress needle is held between the thumb and three fingers and littlefinger rests on abdominal wall as support and guide. It should be angled and pointed towards the pelvis. As the needle pierces the Linea alba and peritoneum the hub moves to resting place. At this stage side to side movements must be free.

To test further the position of the needle-

- Push some saline and it should go without any resistance

- Aspiration should not show any gas, blood, intestinal contents or injected saline.

- The syringe is removed and then saline drop test is performed, the abdominal wall is lifted up & the drop will be sucked in due to negative pressure in the peritoneal cavity. This shows that the needle is in.

- The final confirmation is after the insufflation of abdomen with CO2. The gas tube is connected and insufflation is started with a flow rate of 1-2ltr per/min and intra peritoneal presence of needle can be confirmed:

  - On electronic insufflator indicator.
  - Steady flow of gas.
  - Low pressure in the peritoneal cavity.
  - Symmetrical distension of abdomen.
  - Increasing resonance on percussion over the subphrenic area.

- Increasing resistance by the anesthetist.

Intra-abdominal pressure should be kept between 12-14mm of Hg.

Some surgeons use gasless laparoscopy where special instrument laparolift isused.

INSERTION OF PRIMARY OR FIRST TROCAR

First or primary trocar is a blind port and should be done with all possible precautions. It must be gripped properly; the index finger should be extended along the shaft towards the tip and the hub of the trocar. Infra umbilical abdominal wall is lifted as for Veress needle and trocar is pushed in with slow rotating movements with constant pressure with the palm. A sudden loss of resistance indicates entry into the peritoneal cavity, which is confirmed by hissing sound of escaping gas

The telescope is now inserted and gas tube is connected.
All procedures begin with detailed examination of peritoneal cavity.

Disposable or safety trocars are also available in which as soon as resistance is gone or entered in the peritoneal cavity the sharp tip of trocar will go inside.

Now special trocars are also available where first entry is done under direct vision. The trocar tip is made up of transparent material and it accommodates the telescope so that tissue can be entered under vision.

Whatever type of Veress needle and trocars are used all the safety measures must be followed.

ADDITIONAL OR SECONDARY PORTS

All secondary or additional ports are inserted under vision
i.e., the area must be free from adhesions and no important structure comes in the way. By transilluminating the abdominal wall from inside injury to any veins can be avoided while making incisions or pushing trocars. Site of each port should be far enough so that instruments will have free movements.

VISIBILITY

After white balancing, the telescope is inserted in the peritoneal cavity, condensation may occur on the tip and cause blurred vision. This can be prevented by pre-warming of telescope in hot saline or by applying antifog, Savlon or povidone iodine solution. Drop of the blood on the value of cannula should be wiped. If the blood is smeared over the tip of the telescope can be gently wiped against the liver. If the

vision is still not clear telescope should be removed and cleaned and rewarming or a drop of antifog solution should be applied. If blurred vision persists then focusing, monitor and camera must be checked for any fault.

If 30^{o}telescope is used visibility is better.

Gentle handling of tissue is must at all times to avoid injury and post operative adhesions. Because of long handles of instruments, tissue perception is not as good as in open surgery.

In laparoscopic surgery it is very important that surgeon must be able to recognize anatomical landmarks in peritoneal cavity.

Diathermy must be used very carefully. Tissue must never be cut or cauterized unless seen clearly and non-insulated part of the instrument must be in the field of vision and should not touch any metallic cannula or other instruments. Bipolar cautery is better option.

Before starting a procedure independently, a surgeon must be trained well in laparoscopic surgery and must work with a trained team. He must be able to decide when to abandonthe procedure for open surgery.

During any surgical procedure it is essential to be able to prevent or control bleeding meticulously. In laparoscopic surgery there is often less bleeding because of:

- Intra-abdominal pressure is higher than venous pressure.
- Due to use of warm irrigationsolution.
- View of target tissue is better.
- Proper identification and dissection of vessels is possible.

Ultracision and Lasers are used in laparoscopic surgery.

Various types of clips and staplers are used for different procedures.

Hydro dissection can be used.

Peritoneal lavage should be done to remove blood, fibrin and debris to avoid adhesion formation.

Removal of tissue from the peritoneal cavity should be done under vision and if tissue is big incision may be enlarged. To avoid infection or implantation of ports:

Endo bags should be used

- Cystic lesions are aspirated and removed.
- Solid organs cut in pieces and removed in Endo bags.

Removal of all instrument and ports must be under direct vision.

Suturing of all incisions are done with delayed absorbable or non-absorbable sutures, including the Linea alba.

CHAPTER 3

PATIENT SELECTION AND PREPARATION FOR SURGERY

Preparation for laparoscopic surgery includes.
a) Patient selection.
b) Patient information.
c) Preparation of the theatre.
d) Training of all theatre staff.
e) Preparation and positioning of the patient.

PATIENT SELECTION

When first starting laparoscopic surgery, it is wise to confine yourself to those cases without features indicative of increased technical difficulty.
For laparoscopic cholecystectomy choose thin patients, with functional gall bladders and normal liver function tests.

Avoid those patients who present with the following characteristics until you have gained some experience.

CLINICAL CRITERIA

a) Stocky male patients.
b) Morbid obesity.
c) Previous upper abdominal surgery.
d) Cirrhosis and hepatomegaly.
e) Inflammatory mass in right hypochondrium (acute).
f) Previous severe acute cholecystitis
g) Previous percutaneous stone extraction /MTBE dissolution.

ULTRASOUND / RADIOLOGICAL CRITERIA

a) Gall bladder wall thickness > 4.0 mm
b) Non-contracting gall bladder (US).
c) Stone load: packed gall bladder, large calcified stones (US).
d) Non-functioning gall bladder (XR)

PATIENT INFORMATION

It is very important that all patients undergoing laparoscopic surgery understand that you cannot guarantee to perform their operation laparoscopically – only by the safest method for them at the time of surgery.

- That they will have several small incisions.
- That even though the incisions are small all operations have associated risks.
- They may have post operative shoulder tip pain.
- That they may have to stay in hospital longer than expected if things are not straight forward.
- The consequences of open surgery, should it become necessary

THEATRE AND STAFF PREPARATION

The theatre must naturally be able to supply the relevant equipment and instruments for procedure. In addition, appropriate instruments should be immediately available to cope with emergency complications such as major bleeding.

Spare bulbs for the light source and a spare gas cylinder should be available. This type of surgery places great reliance on technology. If you can begin your laparoscopic experience in a theatre where everyone is familiar with their part in the proceedings, it will be to your advantage.

PREPARATION OF THE PATIENT

a) Anti-embolic stockings.
b) Atropine with the premedication.
c) Prophylactic antibiotics.
d) A standard anesthesia with appropriate monitoring.
e) A urinary catheter is inserted for the duration of the procedure.
f) A nasogastric tube is used to deflate the stomach.
g) The patient is placed supine (the North American approach). As the patient will be tipped during the procedure appropriate measures to ensure their safety are instituted.

CHAPTER 4
GUIDELINES FOR SETTING UP A LAPAROSCOPIC UNIT

INTRODUCTION

The laparoscope has become basic equipment that a surgeon has to use for the diagnosis and treatment of his patients. It has become mandatory today to perform certain procedures like cholecystectomy using laparoscopy. Hence every hospital where general surgery is being performed needs to set up a laparoscopic unit. These are some important points to be considered for selection of equipment and setting up of the operation theatre.

CAMERA

Laparoscopic surgery is today performed using video imaging. The camera, which transmits the image from the telescope to the monitor, is called a C.C.D. (Charge-Coupled Device) Camera. This could be either an analogue or (preferably) a digital camera. They come either as one- chip or three-chip cameras, the latter uses separate chips to identify and analyse the three basic colours (red, blue and green) individually. Hence the colour definition of the image is better in a three-chip camera. The other points to be noted while selecting the camera are:

1. **Resolution:** the image is divided into small squares called pixels and each of these squares are defined separately by the C.C.D. camera. The greater the resolution (the number of pixels), the better is the image definition. Most cameras provide more than 250,000 to 380,000 pixels ofresolution.

2. **Minimum illumination:** This is a factor, which defines the minimum light that is required for the camera to pickup images. The lesser the value the better it is. This becomes more pertinent while operating in bloody field or in the extra-peritoneal region, where light is not reflected back by the glistening surface of theperitoneum.

3. **White balancing**: This is a feature that is a must in all the CCD cameras being used in laparoscopic surgery. The colour of the light being used (e.g. The yellow colour of a halogen light or the blue colour of the xenon light source) is subtracted from the image when a white object is being focussed upon and the white balance switch ispressed.

4. **Automatic adjustments and controls:** There may be additional features in various permutations and combinations in different cameras, such as automatic gain control (helps in brightening dark images), digital zoom, corrections of individual colours, recording facility, various output signals, etc.

MONITOR

The camera is attached to the monitor and ultimately the resolution of the picture displayed is dependent on the resolution of the monitor as well as that of the camera. Most consumer-grade monitors or televisions have 350 lines of horizontal resolution. As far as laparoscopy is concerned, monitors that gives more than 700

horizontal lines are preferred.

GAS INSUFFLATOR

The basic function of the gas insufflator is to maintain the pressure in the abdomen at the set pressure by insufflating gas into the abdomen. There are two kinds of gas insufflators - manual and electronic (high flow). The manual insufflator gives a flow rate of 1 Liter/min. and a high flow of 3 Liters/min. The internal drum in themachine needs to be filled up manually every time it is empty. An electronic insufflator gives a much higher flow rate of up to 30Litres/minute and is much more convenient to use in major surgeries and in instances where suction isfrequently used. The gas either flows interruptedly or continuously based on the technology used in that particular make of the insufflator.

Certain special features that may be included in the electronic gas insufflators are:

Automatic desufflation: When the intra-abdominal pressure rises beyond the set pressure, the gas in the abdomen is automatically desufflated.

Incubated gas: The gas is heated and delivered at a set temperature through the tubing to the abdominal cavity. This helps in preventing fogging of lens during the surgery and also in avoiding hypothermia in cases where lot of gas is used.

Sterilized gas: This may be beneficial where medical grade gases are not available.

LIGHT SOURCE

The three different cold light sources that are used in laparoscopy comprise of halogen, halide and xenon. Each of these lights have their inherent color temperatures and hence do not have an identical brightness. The Xenon light is light blue in color and is the brightest of all. The halide is a white light and the halogen light is yellow in color. Besides it has the lowest brightness of the three, but is commonly used, as it is the most cost-effective option.

TELESCOPE

The rigid telescope used for laparoscopy has a combination of a set of central rod lens and a peripheral rim of fibre optic light bundles. This may be of 10 or 5 mmdiameter. The angle of viewing may be 0 or 30 degrees for most standard procedures. Special features that may be found in different telescopes include wide angle, correction of peripheral distortion and option of autoclaving.

GUIDELINES FOR OPERATING ROOMSETUP

Introduction

The introduction of the laparoscope into the surgeon's basic armamentarium has resulted in the need for more sophistication and greater planning to set up a laparoscopic operating suite. Proper designing ensures greater ease of personnel movement, decreases clutter, improves ergonomics, maintains the sterile field, and facilitates the use of advanced imaging and display devices. This also ensures that

the basic components are in place and functioning. Enlisted herein are some basic guidelines in setting up a laparoscopic operating suite.

1. The usual requirements for a good operation theatre are necessary and not elaborated in this article.

2. Operating Room Size has to be adequate for easy placement of equipment and to make necessary changes according to surgeon's requirements. It should also facilitate free movement of OT personnel.

3. In a large room the operating table is to be positioned normally and in a smaller room the operating table can be placed diagonally.

4. Doors and Windows should be opacified to prevent unwanted light.

5. Cables should run the shortest possible distance, not to be left dangling and hinder movement of OT personnel.

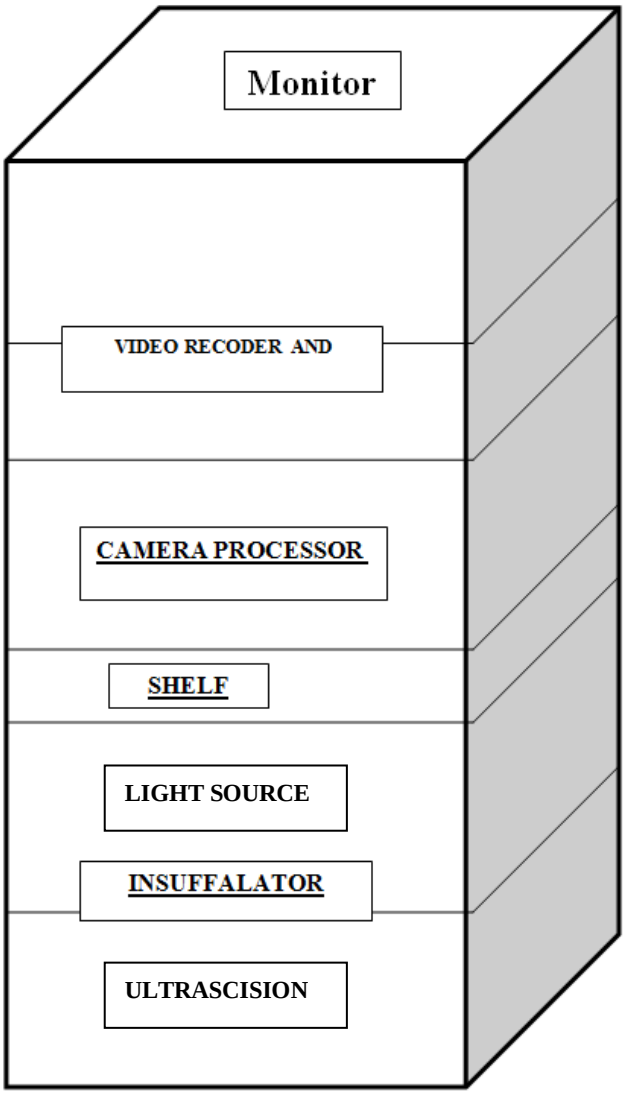
6. Multiple electrical points should be available on the equipment trolley. Multiple plug points are to be provided around the room so that when the trolley ismoved around, the electric cable from the trolley to the wall is maintained at the shortest distance. It is preferable to isolate the electrosurgical unit from other equipment to avoid electrical disturbances.

7. Proper earthing has to be provided and there should be an uninterrupted power supply with adequate power back up. It is also necessary to use voltage stabilizer and surge suppressor to avoid inadvertent damage to sensitive electronic equipment.

8. Two full Co2 Cylinders one of which will be stand by.

9. The operating team may be more comfortable standing on footstools, to compensate for the increased height due to usage of long instruments. These footstools have to be broad to accommodate the surgeon and foot pedals.

10. Laparoscopic equipment is generally housed in a cart on wheels to facilitate its movement around the operation table. Optimal height of the equipment trolley is 5 feet. The equipment is ideally arranged as shown in the figure.



11. Use footboard and extra safety straps for large patients

12. A dedicated team is the primary requirement and it ensures better co-ordination, decreases operating time, improves patient care, and decreases cost to the patient and institution

13. Preparation for conversion to open surgery is necessary for every case being taken up for laparoscopy.

14. Surgeon should preferably come to OT sufficiently early to facilitate correct placement of equipment and to ascertain that all instruments necessary are available and functioning.

15. A checklist is mandatory to ensure availability and proper functioning of all equipment and instruments at the beginning of the day and also before. It also prevents unnecessary delays during surgery and anesthesia.

An example for standard check-list for any surgery is as follows:

Principles include.

a. Laparoscope to point at the site of operation

b. Surgeon stands opposite the pathology and looks at the monitor.

c. Surgeon, camera, organ being operated uponand monitor to be in a straight line

THE FUTURE

1. The development of ergonomically adequate handle designs and efficient methods of handle to tip force transmission remains an interesting quest

2. The advent of the robotic arm will abolish the need for assistance and provide greater ability of view, less inadvertent smearing of the lens, and the absence of fatigue. Further robots may perform surgeries in the future

3. We would take the laparoscope out of the operation theater as an informative diagnostic tool.

4. The informative age is bringing in digitization of all equipment and hence imaging, documentation and handling equipment and instrumentation is going to radically change.

5. "Image guided surgery" may transform the way we operate on our patients.

References

1. THE SAGES MANUAL Fundamentals of Laparoscopy and GIEndoscopy

2. TEXT BOOK OF SURGICAL LAPAROSCOPY C. Palanivelu

3. Boyers SP. Operating room setup andinstrumentation**.** *Clin ObstetGynecol 1991 Jun;34(2):373-86*

4. **Herron DM, Gagner M, Kenyon TL, Swanstrom LL** The minimally invasive surgical suite enters the 21st century. A discussion of critical design elements**.** *Surg Endosc 2001 Apr;15(4):415-22* RelatedArticles,

5. **Winer WK.** Nursing aspects of gynaecologicendoscopy.*SurgAllied Technol1995 Apr-Jun;3(2-3):109-11*

6. **WattiezA, Pouly JL, Mage G, Canis M, Manhes H, Bruhat MA.** Operative celioscopy: needs and innovations in equipment]*JGynecolObstet Biol Reprod(Paris)1990;19(5):554-6Links*

7. **Kenyon TA, Lenker MP, BaxTW, Swanstrom LL** Cost and benefit of the trained laparoscopic team. A comparative study of a designated nursing team vs a nontrained team.SurgEndosc 1997 Aug;11(8):812- 4RelatedArticles,

8. **Bachmann GA, TrattlerB, Ko T, TweddelG.**Operational improvement of gynecologic laparoscopic operating room services: an internal review.*ObstetGynecol 1998Jul;92(1):142-4*

9. **Winer WK.**The Role of the "O.R. Personnel" for Operative GynecologicEndoscopy
J Am Assoc GynecolLaparosc 1994 Aug;1(4, Part 2):S39-40

10. **Alarcon A, Berguer R.**A comparison ofoperating room crowding between open and laparoscopic operations.*SurgEndosc 1996 Sep;10(9):916-9*

11. **Matern U, Waller P, Giebmeyer C, Ruckauer KD, FarthmannEH.**Ergonomics:requirementsforadjusting the height of laparoscopic operating tables. *JSLS 2001 Jan-Mar;5(1):7-12*

12. **Khaitan L, Chekan E, Brennan EJ Jr, Eubanks S.**Diagnostic laparoscopy outside of the operating room.SeminLaparosc Surg 1999Mar;6(1):32-40

13. **Miller JK, Pepin SR.**Microsurgical instrument handling systems. A new approach to instrument budget control**.** *TodaysOR Nurse 1993Jul-Aug;15(4):43-50*

14. **Colver RM.**Laparoscopy: basic technique, instrumentation, andcomplications.
Surg LaparoscEndosc 1992 Mar;2(1):35-40

15. **Seus JD, Wood T.**Reapingmaximum benefits from minimally invasive surgery. *J Healthc Mater Manage 1994Aug;12(8):20-4*

16. **Deardorf MA** Increasing multipuncture laparoscopic instrument longevity. *AORN J 1991 Aug;54(2):357-8, 360*

17. **Matern U, Ruckauer KD, Farthmann EH** [Working posture of laparoscopy-practicing surgeons: ideal and reality] *ZentralblChir2000;125(8):698-701*.

*18.***Kenyon TA, Urbach DR, Speer JB, Waterman- Hukari B, Foraker GF, Hansen PD, Swanstrom LL.** Dedicated minimally invasive surgery suites increase operating room efficiency. *Surg Endosc 2001 Oct;15(10):1140-3*

*19.***DivilioLT.** Improving laparoscopic visibility and safety through smoke evacuation.*SurgLaparoscEndosc 1996Oct;6(5):380-4*

20. **Lingard L, Reznick R, Espin S, Regehr G, DeVito I.** Team communications in the operating room: talk patterns, sites of tension, and implications for novices. *Department of Pediatrics, University of Toronto, Ontario,Canada*

21. **Crow S.** Protecting patients, personnel, instruments in the OR. *AORN J 1993Oct;58(4):771-4*

22. **Winer WK, Lyons TL.** Suggested set-up and layout of instruments and equipment for advanced operative laparoscopy. *J Am Assoc GynecolLaparosc 1995 Feb;2(2):231-4*

23. **Eaves FF 3rd, Bostwick J 3rd, Nahai F.** Instrumentation and setup for endoscopic plastic surgery. *Clin PlastSurg 1995Oct;22(4):591-603*

24. **Dorsey JH.** Operating room organization. Lasers and advanced operative laparoscopy. *ObstetGynecol Clin North Am 1991Sep;18(3):569-74*

25. **Ballantyne GH** The pitfalls of laparoscopic surgery: challenges for robotics and telerobotic surgery. *Surg LaparoscEndoscPercutanTech 2002Feb;12(1):1-5*

26. **Paolucci V, Schaeff B, Gutt C, Morawe G, Encke A.** [Disposable versus reusable instruments in laparoscopic surgery--a controlled study] *ZentralblChir1995;120(1):47-52.*

27. **Pfeifer E** Processing of surgical instruments for minimally invasive surgery. *EndoscSurgAllied Technol 1994Oct;2(5):282*

28. **Burkhart NW,Crawford J.** Critical steps in instrument cleaning: removing debris after sonication. *J Am Dent Assoc 1997Apr;128(4):456-63.*

29. **Duppler DW**. Laparoscopicinstrumentation,

videoimaging, and equipment disinfection and sterilization.Surg Clin North Am 1992 Oct;72(5):1021- 32

30. CheahWK,LenziJE,SoJ,DongF,KumCK,Goh P. Evaluation of a head-mounted display (HMD) in the performance of a simulated laparoscopic task. *Surg Endosc 2001 Sep;15(9):990-1*

31. **Girotti MJ, Nagy AG, Litwin DE, Mamazza J, Poulin EC**.Laproscopic surgery basic armamentarium.*Can J Surg 1992Jun;35(3):281-4*

32. **Lerguer R.** Surgical technology and the ergonomics of laparoscopic instruments.*: Surg Endosc 1998 May;12(5):458-62.*

33. **Spellman JR** Laparoscopic equipment troubleshooting..*Todays OR Nurse 1995 Jan- Feb;17(1):13-22*

34. **Moir CR.**Diagnostic laparoscopy and laparoscopic Equipment. *Seminars PeadSurg 1993 Aug;2(3):148- 58*

35. Proper Maintenance of Instruments Working Group InstrumentPreparation.

36. **Voyles CR, Sanders DL, Simons JE, McVey EA, Wilson WB**.Steam sterilization of laparoscopic instruments. *Surg LaparoscEndosc 1995 Apr;5(2):139-41*

37. : **Roth K, Heeg P, Reichl R**. Specific hygiene issues relating to reprocessing and reuse of single-use devices for laparoscopic surgery. *Surg Endosc2002;16(7):1091-7*

38. **Fengler TW,Pahlke H, Kraas E** [Laparoscopic instruments in practical clinical tests--prospective study of functional aspects and residual contamination*]. LangenbecksArch Chir Suppl Kongressbd1997;114:1235-7*

39. **Seifman BD, Wolf JS Jr**. Technical advances in laparoscopy: hand assistance, retractors, and the pneumodissector. *J Endourol 2000 Dec;14(10):921-8*.

40. **Moir CR.**Diagnostic laparoscopy and laparoscopic Equipment. *Seminars Pead Surg 1993 Aug;2(3):148- 58.*

Chapter 5
ENDOVISION

Introduction to Endovision Systems in Laparoscopic Surgery

The advent of laparoscopic surgery marked a new era in the world of minimally invasive surgical procedures. Endovision systems, an integral part of these procedures, play a pivotal role in providing the surgeon with a detailed internal view of the patient's body, thereby maximizing precision and ensuring safer surgical outcomes.

The term 'Endovision' is derived from 'Endo', meaning 'inside', and 'Vision', denoting the ability to see. Thus, endovision systems offer a real-time visual representation of the internal structures of the patient's body. They use a combination of high-resolution cameras, powerful light sources, and state-of-the-art display systems to create an amplified visual field for the surgeon (Soper, N.J. & Stockmann, P.T., 1992) [1].

The use of endovision systems has revolutionized laparoscopic surgery by allowing surgeons to perform complex procedures through tiny incisions with enhanced precision, reduced blood loss, and minimized post-operative pain and recovery time. The visual information provided by these systems has expanded the possibilities of minimally invasive surgery, leading to improved patient outcomes.

The journey towards the contemporary endovision systems traces back to the 1980s. Semm, K. (1983) was one of the pioneers who laid the foundation for endoscopic intraabdominal surgery[2].

Over the years, these systems have evolved from single-chip cameras to the three-chip systems, and now to the high-definition, 4K, and 3D cameras. The evolution of light sources, monitors, and other accessories has also contributed to the overall enhancement of the endovision system.
Today, endovision systems form an indispensable part of laparoscopic surgery, and the continuous technological advancements in this field promise an exciting future.

Components of an Endovision System

The endovision system is a composite of several key components, each contributing to the overall performance and efficacy of the system. The primary components of an endovision system are the camera systems, light sources, monitors or display systems, and insufflators. Each of these plays a unique role in the visualization process during laparoscopic surgery (Soper, N.J. & Stockmann, P.T., 1992)[3].

Camera Systems

The camera system forms a vital link in the imaging chain of laparoscopic surgery, transforming the optical image formed by the laparoscope into an electronic signal that can be displayed on a monitor. Modern endoscopic camera systems vary greatly in their complexity and capabilities, ranging from single-chip cameras to advanced three-chip and stereoscopic systems.

- **Single-Chip Cameras:**
  Single-chip cameras are the simplest type of endoscopic camera system. These cameras use a single charge-coupled device (CCD) or complementary metal-oxide-semiconductor (CMOS) sensor to capture all colour information (red, green, and blue) at each pixel site. While these cameras are relatively inexpensive and compact, they suffer from lower colour resolution compared to three-chip cameras.

- **Three-Chip Cameras:**
  Three-chip cameras, also known as 3-CCD cameras, are the standard in many modern laparoscopic surgeries due to their superior image quality. In these cameras, the incoming light is split into three primary colours using a beam-splitter. Each colour is then captured by a separate CCD or CMOS sensor, greatly enhancing the camera's colour resolution and image quality. However, these cameras are more complex and expensive than single-chip systems.

- **High Definition Cameras:**
  High definition (HD) cameras offer higher resolution images compared to standard-definition (SD) systems. HD cameras capture images at a resolution of at least 1280x720 pixels (720p), with some systems offering 1920x1080 pixels (1080p) or even higher. The increased resolution allows for more detail to be seen, improving the surgeon's ability to identify and differentiate anatomical structures.

- **3D or Stereoscopic Cameras:**
  Stereoscopic cameras consist of two slightly spaced cameras that capture two distinct images, mimicking the binocular vision of the human eye. These images can be processed to create a 3D effect, giving the surgeon a sense of depth in the surgical field. This can potentially improve surgical precision and reduce operation times. However, these systems require specialized monitors and glasses, and some surgeons may experience discomfort or disorientation when using 3D visualization.

- **Fluorescence Imaging (FI)**
  Near-infrared (NIR) fluorescence imaging has recently experienced rapid expansion on a global scale. It aims for the best patient outcome during diagnostics or surgery. In minimally invasive surgery it is used in numerous applications such as vessel or visceral perfusion assessment, visualization of bile duct anatomy or (sentinel) lymph node mapping.

- **Enhanced Visualization:**
  One significant advance has been the improvement in camera sensitivity, allowing for better visualization of fluorescent signals. This enhancement has resulted in clearer and more detailed images during laparoscopic procedures. Surgeons can now detect even subtle fluorescent signals, which is particularly useful for identifying small lesions or tumors that might be challenging to spot with traditional imaging techniques.

  The availability of new and improved fluorescent dyes has expanded the

applications of fluorescence imaging in laparoscopy. These dyes can specifically target certain tissues or biomarkers, making it easier to differentiate between healthy and diseased tissues during surgery. For instance, certain dyes can highlight blood vessels, lymph nodes, or cancer cells, aiding surgeons in making more precise decisions during the procedure. Surgeons can now observe the fluorescence during the surgery itself, rather than relying solely on preoperative imaging. This real-time feedback allows for more accurate and immediate decision-making during the procedure, potentially reducing the risk of complications and improving patient outcomes.

Some systems now incorporate multispectral imaging capabilities, enabling the simultaneous capture of multiple fluorescent signals with different wavelengths. This advancement allows for a more comprehensive assessment of tissues, providing surgeons with a more comprehensive understanding of the surgical site. Laparoscopic fluorescence imaging has started to integrate with surgical navigation systems. Surgeons can overlay the fluorescence data onto the live camera feed or 3D models of the patient's anatomy, providing valuable guidance during complex procedures. However, it is crucial to stay up-to-date with the latest developments in the field to fully grasp the current state of this technology.

Laparoscopes

A laparoscope is an essential component of the imaging chain in laparoscopic surgery, acting as the gateway between the internal surgical field and the external imaging system. It is a long, thin instrument equipped with a light channel that introduces light into the body cavity and a lens system that captures the reflected light and forms an image.

There are primarily two types of laparoscopes: rigid and flexible. The former is more commonly used in laparoscopic surgery.

- **Rigid Laparoscopes:**
  Rigid laparoscopes consist of a series of rod lenses developed by Harold H. Hopkins, which provides high image quality and light transmission [1]. They are generally 5-10 mm in diameter and 33-45 cm in length, with variations designed for specific procedures.

  Rigid laparoscopes can further be classified based on the angle of view they provide: such as 0°, 30°, 45°, 70°. Most commonly used is the 30° telescope as it provides better vision of all the different sides of organs, especially for pelvic surgeries. 45° telescopes are preferred in some advanced surgeries such as bariatric procedures.

  GRIN Lenses
  GRIN stands for Gradient-Index lenses. These lenses are a type of optical component that exhibits a gradual change in refractive index along its length. Unlike conventional lenses with a uniform refractive index, GRIN lenses can bend light in a way that allows them to focus or collimate light without the need for complex optical systems. GRIN lenses in laparoscopic imaging

systems are used to enhance image quality and reduce the size of the endoscopic equipment

- **Flexible Laparoscopes:**
  Flexible laparoscopes, though less common in laparoscopic surgery, offer the advantage of adjustability, providing an ability to navigate through tortuous pathways. They utilise a fibre-optic bundle for image transmission, which may result in lesser image quality compared to rigid scopes.

Light Sources

The light source is the beginning of the imaging chain in laparoscopic surgery, and it critically influences the quality of the endoscopic image. The light produced by the source is carried by a fiber optic cable into the patient's body cavity through the laparoscope, illuminating the surgical field. The four common types of light sources used in endoscopy include halogen, xenon, metal halide, and LED, with each having distinct properties.

Benefits of an effective light source include:

- Tissue Differentiation: Proper illumination helps distinguish tissues and structures, enabling surgeons to identify anatomical landmarks and make precise surgical manoeuvres.
- Depth Perception: Adequate lighting aids in creating a three-dimensional perception, allowing surgeons to assess the depth and spatial relationships within the surgical field accurately.
- Colour Rendering: Accurate colour representation is essential for the identification of blood vessels, tissues, and pathologies during laparoscopic procedures.

1. Halogen:

Halogen light sources were commonly used in early laparoscopic surgeries. They produce a yellowish light with a colour temperature around 3200 Kelvin. While halogen lamps are inexpensive, they generate significant heat and have a relatively short lifespan of about 50 hours. Moreover, their lower colour temperature renders a less natural colour representation compared to xenon or LED light sources.

2. Xenon:

Xenon light sources are popular in modern laparoscopic surgeries due to their high-intensity, white light output that closely mimics daylight, with a colour temperature ranging from 5700 to 6000 Kelvin. They offer excellent colour rendition, allowing for better tissue differentiation. However, xenon lamps have a higher cost and typically last between 500 to 1000 hours.

3. Metal Halide:

Metal halide lamps provide a light output that is similar to xenon, with a slightly lower colour temperature (about 5400 Kelvin). They offer a longer lifespan (around 1500 hours) than xenon lamps but can require more time to reach their full light output after being switched on.

4. LED:

LED (Light Emitting Diode) light sources are increasingly being used due to their numerous advantages. LEDs have a long lifespan, often up to 50,000 hours, greatly reducing the need for replacements. They also consume less energy, produce less heat, and reach their full light output almost instantaneously. LED light sources provide a colour temperature similar to daylight (around 6000 Kelvin), rendering excellent colour reproduction.
In addition to visible light, infrared (IR) light can also be utilised in some laparoscopic applications. For instance, near-infrared (NIR) fluorescence imaging uses IR light to illuminate specific dyes injected into the patient, allowing for the visual differentiation of structures like lymph nodes or bile ducts.

Monitors and Display Systems
Monitors and display systems act as the interface between the camera and the surgeon. They display the images captured by the camera, allowing the surgeon to view and interpret the ongoing procedure. The quality of the monitor significantly impacts the clarity and detail of the visual information. Modern display systems often feature high-definition or 4K monitors and may also support 3D visualization.

Monitors commonly used in laparoscopy are:

1. **Standard Definition (SD) Monitors:** These are the most basic monitors used in laparoscopy. They have a lower resolution and may not provide the same level of image clarity as higher-definition options.

2. **High Definition (HD) Monitors:** HD monitors offer better image quality with higher resolution, allowing for more detailed visualization during laparoscopic procedures.

3. **Three-Dimensional (3D) Monitors:** 3D monitors provide a three-dimensional view of the surgical field, which can enhance depth perception and spatial awareness during laparoscopic surgeries.

4. **4K Ultra High Definition (UHD) Monitors:** These monitors offer even higher resolution than HD monitors, providing incredibly sharp and clear images, which can be beneficial for complex surgical procedures.

5. **Touchscreen Monitors:** Some laparoscopic systems come with touchscreen monitors, allowing surgeons to control certain aspects of the equipment directly on the screen.

Aspect Ratio:
Aspect ratio is a term used to describe the proportional relationship between the width and height of an image or a screen. It is typically expressed as two numbers separated by a colon, such as 16:9 or 4:3. The first number represents the width, and the second number represents the height.

The most common aspect ratios for surgical monitors are 16:9 and 4:3.

- **16:9 Aspect Ratio**: This widescreen aspect ratio is prevalent in modern surgical monitors. It provides a wider viewing area, which is beneficial for displaying high-definition (HD) or ultra-high-definition (UHD) content during surgeries. The 16:9 aspect ratio allows for clear visualization of surgical images and videos with enhanced detail.
- **4:3 Aspect Ratio**: While less common in modern surgical monitors, the 4:3 aspect ratio was more prevalent in older monitor models. Some legacy systems or medical equipment might still use monitors with this aspect ratio.

Colour Model:
A colour model is a system used to represent colours in a visual display. It defines how colours are encoded and displayed on the screen.

One of the most commonly used colour models in surgical monitors and medical imaging is the RGB colour model (Red, Green, Blue). In this model, colours are created by combining varying intensities of red, green, and blue light.

The RGB colour model allows for the display of a wide range of colours, providing surgeons and medical professionals with a detailed and realistic view of medical images and videos. High-quality surgical monitors often use a wide-gamut RGB colour space, which can accurately reproduce a broad spectrum of colours found in medical imaging.

Colour Depth:
Colour depth, also known as bit depth, refers to the number of bits used to represent each pixel on the screen. It determines the number of colours that can be displayed. Common colour depths for surgical monitors include 8-bit, 10-bit, and 12-bit. The higher the bit depth, the more colours can be accurately represented.

Higher colour depth allows for smoother colour gradients and reduces the likelihood of colour banding, which is essential when displaying medical images with subtle colour variations or gradients. Monitors with higher colour depth are preferred in medical settings to ensure accurate and precise visualization during surgical procedures.

Accurate colour representation and depth are crucial in surgical monitors because they directly impact the ability of surgeons to make critical decisions based on visual information. Medical-grade monitors with advanced colour calibration and wide colour gamut are used to ensure the highest level of accuracy in displaying medical images and videos during surgical interventions and diagnostic procedures.

Interlaced and Progressive Displays:

1. **Interlaced:**
   Interlaced is an older method of displaying images on screens. It was more commonly used in older CRT (Cathode Ray Tube) monitors and televisions. In interlaced displays, each frame of the image is divided into two fields, referred to as odd and even lines. The odd lines are displayed first, and then the even lines are displayed in the next refresh cycle.

The advantage of interlaced displays was that they could provide a perception of motion with a lower bandwidth requirement because only half of the image lines were updated at a time. However, interlaced displays could sometimes lead to a flickering effect and reduced image clarity, especially with fast-moving content.

2. **Progressive:**
Progressive is the more modern and standard method of displaying images on screens. It is commonly used in modern monitors, HDTVs, and other display devices. In progressive displays, each frame of the image is displayed sequentially, line by line, without splitting into fields. The entire image is updated in each refresh cycle.

Progressive displays provide smoother motion, improved image clarity, and reduced flickering compared to interlaced displays. The majority of digital content, including high-definition video and computer graphics, is designed for progressive displays.

Video Connectors

2.5 Video Connectors

Connector	Video Signal	Audio Signal	Maximum Resolution	3D Support	Images
DVI (Digital Visual Interface)	Digital	No	1920x1200 at 60Hz	No	
SDI (Serial Digital Interface)	Digital	Yes	1080p at 60Hz (SDI), 2160p at 60Hz (12G-SDI)	No	
HDMI (High-Definition Multimedia Interface)	Digital	Yes	7680×4320 at 60Hz (HDMI 2.1)	Yes	
VGA (Video Graphics Array)	Analog	No	2048x1536 at 85Hz	No	

DisplayPort	Digital	Yes	7680×4320 at 60Hz (DisplayPort 2.0)	Yes	
USB-C (with DisplayPort Alt Mode)	Digital	Yes	Depends on DisplayPort version	Depends on Display Port version	

Recording, Editing, and Storage

In the realm of modern laparoscopic surgery, the ability to record, edit, and store surgical procedures is of paramount importance. The ability to capture and revisit these procedures provides immense value for documentation, medico-legal evidence, surgeon training, surgical innovation, and research.

Recording

The first step in the process is the actual recording of the surgery. This is typically done by the camera control unit (CCU) that is connected to the laparoscope. These CCUs usually have built-in recording functionalities, allowing for both video and still image capture. The recording is typically initiated and controlled by the surgical team or a dedicated recording technician. The resolution, frame rate, and format of the recording can vary based on the capabilities of the CCU and the desired quality of the recorded video].

For good quality recording and streaming the entire flow should be of the same quality as your telescope and camera.
For example, if the camera is in Full HD format and regular composite video output is being used, you will not get the best result output. So, it is essential to use DVI/HDMI for Monitor and 3G SDI Output from the camera to the recording and streaming device for the best possible result. In the same way for a 4k camera you must use DVI/HDMI for Monitor and 12G SDI Output from camera to the recording and streaming device for best possible result.
It must be ensured that the recording and streaming device supports Full HD / 4k capabilities depending on the camera.

Note: For Streaming Full HD and 4K videos you a high speed dedicated internet lease line is necessary. For best results HDMI cables shouldn't be used for more than 5mtrs. For longer distance you can convert the DVI / HDMI to 3G SDI for HD and 12G SDI for 4K using the converters. 3G SDI Cable can go up to 80mtrs and 12G SDI cable for 30mtrs. For longer distances there are other solutions depending on the specific requirements.

Editing

Following the recording, the raw video footage can be edited to remove unnecessary portions, enhance the visual clarity, or annotate with relevant surgical findings and steps. This process can be carried out using various video editing software packages, and the edited video can then be exported in a desired format. It is important to note

that the original raw footage should always be preserved in its unedited form for medico-legal purposes.

Storage

There are three main categories of storage devices: optical, magnetic and semiconductor. The earliest of these was the magnetic device. Computer systems began with magnetic storage in the form of tapes. These graduated to the hard disk drive and then to a floppy disk. DAS devices include floppy disks, optical discs—compact discs (CDs) and digital video discs (DVDs)—hard disk drives (HDD), flash drives and solid-state drives (SSD). Network-based storage allows more than one computer to access it through a network, making it better for data sharing and collaboration. Network-attached storage (NAS) is a file-level (as opposed to block-level storage) computer data storage server connected to a computer network providing data access to a heterogeneous group of clients.

The storage of recorded videos has seen a tremendous shift in recent years. With the advent of cloud storage, videos can now be uploaded and stored securely online. This allows for easy access and sharing of videos across various locations and devices, and also removes the risk of loss due to physical damage or degradation over time. It also ensures that a large volume of high-resolution videos can be stored without running out of space. However, due consideration must be given to patient confidentiality and data protection when using cloud storage.

Advancements in Endovision Systems

Continuous advancements in technology have significantly impacted endovision systems, enhancing their capability and application in laparoscopic surgery. Some of the key advancements in recent years include the development of robotic systems, fluorescence imaging, and enhanced reality systems.

Robotic Systems and Endovision

One of the most significant advancements in laparoscopic surgery is the integration of robotic systems. The da Vinci Surgical System, for example, uses a 3D high-definition vision system that allows surgeons to view the surgical field with true depth perception and a high degree of magnification. This results in a more precise visualization of the operating field and allows for enhanced precision and control during the surgery (Seagull, F.J. & Cao, C.G.L., 2008)[6].

Fluorescence Imaging

Another significant development in endovision systems is the use of fluorescence imaging. This technology uses a fluorescent dye that is absorbed by the tissues and then emits light when illuminated with a specific wavelength. The camera system captures these signals and transforms them into an image that allows surgeons to visualize specific tissues or structures clearly. This can be particularly useful in identifying critical structures such as blood vessels, lymph nodes, and tumors during surgery (van Manen, L. et al., 2018)[7].

Enhanced Reality Systems

Enhanced reality (ER) systems represent another emerging field in laparoscopic

surgery. These systems overlay preoperative and intraoperative imaging data onto the real-time view of the surgical field, providing surgeons with additional contextual information. This can improve the understanding of complex anatomical structures and assist in surgical navigation.

In conclusion, advancements in endovision technology are expanding the capabilities of laparoscopic surgery and improving surgical outcomes. The continuous evolution of these technologies presents exciting possibilities for the future of minimally invasive surgery.

Future Perspectives of Endovision Systems in Laparoscopic Surgery

As we look to the future, it is clear that endovision systems will continue to evolve, leading to further improvements in laparoscopic surgery. The rapid pace of technological advancements, combined with an increased understanding of surgical techniques and processes, promises exciting developments in the field.

AI-Enhanced Endovision Systems

The application of artificial intelligence (AI) in healthcare is burgeoning, and its integration into endovision systems will likely transform laparoscopic surgery. AI algorithms can enhance surgical imaging, automate routine tasks, and even aid in surgical decision-making. For instance, AI could provide real-time recognition of anatomical structures and abnormal tissues, thus improving surgical accuracy and patient safety (Hashimoto, D.A., Rosman, G., Rus, D., & Meireles, O.R., 2018)[15].

Augmented Reality (AR) and Virtual Reality (VR) in Surgery

Augmented reality (AR) and virtual reality (VR) technologies are finding their way into the surgical realm. They promise to merge real-time imaging with preoperative and intraoperative data to provide a comprehensive visualization of the surgical field. This can facilitate better surgical planning and real-time navigation during surgery (Bernhardt, S., Nicolau, S.A., Soler, L., & Doignon, C., 2017)[16].

Miniaturization of Endovision Systems

The miniaturization of endovision systems will be a significant leap forward, allowing for even less invasive procedures. Innovations like micro-endoscopes and 'pill cameras' can provide detailed imaging while causing minimal discomfort to the patient. This can also extend the reach of endoscopic procedures to previously inaccessible regions of the body (Sakata, S. et al., 2017)[17].

Enhanced Training Tools

With the growing complexity of endovision systems, there will be an increased focus on creating effective training tools. This could involve the use of virtual or augmented reality for simulation training, enhancing the proficiency of surgeons in handling these advanced systems (Stefanidis, D. et al., 2010)[18].

In conclusion, while there are already impressive advances in endovision systems, the future promises even more significant leaps forward. As technology continues to

evolve, so too will the capabilities and applications of endovision systems in laparoscopic surgery.

References:

1. Soper, N. J., & Stockmann, P. T. (1992). Laparoscopic cholecystectomy. The state of the art. Surgical Clinics of North America, 72(5), 1007-1022.
2. Semm, K. (1983). Endoscopic intraabdominal surgery. Endoscopy, 15(02), 59-64.
3. Soper, N. J., & Stockmann, P. T. (1992). Laparoscopic cholecystectomy. The state of the art. Surgical Clinics of North America, 72(5), 1007-1022. ↩
4. Sakata, S., Grove, P. M., Hill, A., Watson, M. O., & Stevenson, A. R. (2017). Impact of simulated three-dimensional perception on precision of depth estimation in vitro. Surgical endoscopy, 31(1), 436-443
5. Seagull, F. J., & Cao, C. G. L. (2008). Situation awareness, confidence, and performance with a robotic surgical system. Applied ergonomics, 39(4), 503-509. ↩
6. van Manen, L., Handgraaf, H. J., Diana, M., Dijkstra, J., Ishizawa, T., Vahrmeijer, A. L., & Mieog, J. S. (2018). A practical guide for the use of indocyanine green and methylene blue in fluorescence-guided abdominal surgery. Journal of Surgical Oncology, 118(2), 283-300.
7. Soper, N. J., & Stockmann, P. T. (1992). Laparoscopic cholecystectomy. The state of the art. Surgical Clinics of North America, 72(5), 1007-1022. ↩
8. Nezhat, C., Main, J., Paka, C., Nezhat, A., & Beygui, R. E. (2014). Advanced gynecologic laparoscopy in a fast-track ambulatory surgery center. JSLS: Journal of the Society of Laparoendoscopic Surgeons, 18(1), 1-5. ↩
9. Seagull, F. J., & Cao, C. G. L. (2008). Situation awareness, confidence, and performance with a robotic surgical system. Applied ergonomics, 39(4), 503-509. ↩
10. Yan, T.D., Black, D., Bannon, P.G., McCaughan, B.C. (2006). Systematic review and meta-analysis of randomized and nonrandomized trials on safety and efficacy of video-assisted thoracic surgery lobectomy for early-stage non–small-cell lung cancer. Journal of Clinical Oncology, 24(15), 2553-2562.
11. Hanna, G. B., Shimi, S. M., & Cuschieri, A. (1998). Task performance in endoscopic surgery is influenced by location of the image display. Annals of Surgery, 227(4), 481. ↩
12. Gurusamy, K. S., Samraj, K. (2008). Abdominal insufflation for laparoscopic cholecystectomy. Cochrane Database of Systematic Reviews, Issue 2. Art. No.: CD006204. DOI: 10.1002/14651858.CD006204.pub2. ↩
13. Stefanidis, D., Hope, W.W., Korndorffer, J.R., Markley, S., & Scott, D.J. (2010). Initial laparoscopic basic skills training shortens the learning curve of laparoscopic suturing and is cost-effective. Journal of the American College of Surgeons, 210(4), 436-440
14. Hashimoto, D.A., Rosman, G., Rus, D., & Meireles, O.R. (2018). Artificial intelligence in surgery: Promises and perils. Annals of Surgery, 268(1), 70-76. ↩
15. Bernhardt, S., Nicolau, S.A., Soler, L., & Doignon, C. (2017). The status of augmented reality in laparoscopic surgery as of 2016. Medical Image Analysis, 37, 66-90. ↩
16. Sakata, S., Grove, P. M., Hill, A., Watson, M. O., & Stevenson, A. R. (2017). Impact of simulated three-dimensional perception on precision of depth estimation in vitro. Surgical endoscopy, 31(1), 436-443. ↩
17. Stefanidis, D., Hope, W.W., Korndorffer, J.R., Markley, S., & Scott, D.J. (2010). Initial laparoscopic basic skills training shortens the learning curve of

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CHAPTER 6

OPEN LAPAROSCOPY

One of the great inventions in the history of laparoscopy has been the invention of Veress needle. Introduction of a needle into the peritoneal cavity to insufflate gas which was considered to be a risky procedure was made 'safe' by this spring loaded needle. Complications decreased and perhaps laparoscopy became much more popular after this invention. But is this needle really so safe as to use it without any complications. Review of literature in the 70s and 80s show that almost 70 to 80% of all complications of laparoscopy are related to the introduction of the Veress needle or the primary trocar into the abdominal cavity.

In fact there has been a continual improvisation in the type of trocars that have been used for the first blind entry, but they have all proved to be either associated with enough complications or have been an expensive proposition.

Almost two decades ago Harith Hasson in U.S.A., described open laparoscopy, which actually meant opening the peritoneum and visually introducing a blunt trocar- canula into the abdomen. Several specialists transformed their procedure to 'Hasson's technique', but several more remain faithful to the Veress needle. It is surprising that though Hasson himself is a gynaecologist, more surgeons all over the world use open laparoscopy and gynaecologists have somehow remained averse to it.

Most gynaecologists, over the last decade or so have remained experts in laparoscopy in our country, thanks to the thousands of laparoscopic sterilizations they have had to perform. The scenario is fast changing. With more and more specialists and centers coming up the exposure each one gets is being minimised. We have patients coming for repeat surgeries much more often today. With the advent of video-laparoscopy there is hardly any gynaecological surgery that needs a laparotomy. The risk of adhesions in repeat surgeries tilts the balance against the blind introduction of the Veress needle or the trocar. With increase inflammatory conditions, we need not have adhesions only in patients with previous surgeries but also in 'so-called normal' individuals. The answer to safe practice of laparoscopy is certainly open laparoscopy and this is becoming more and more obvious.

Open laparoscopy means introduction of the trocar into the peritoneal cavity after dissection and incision of the peritoneum and visualization of the abdominal cavity. This technique prevents 3 blind procedures:

1. Introduction of Veress needle
2. Insufflation of Carbon dioxide gas through the needle.
3. Introduction of the trocar.

It is only after these three blind procedures that we introduce a telescope and are able to ensure whether there was any damage done or not.
The procedure of open laparoscopy can be made easy by having a few small but very useful instruments as a set with our laparoscopic instruments. These include 2

small sized Allis (4 inch length), 2 straight artery forceps, 2 mosquito forceps and a pair of small right angled retractors. I generally use Ethibond or P.D.S. suture material, as this can be conveniently used to close the fascial defect at the end of the surgery.

A subumbilical incision is taken by stretching the abdominal skin downwards, so that the incision actually becomes intra-umbilical to give a better cosmetic scar. This is a curved incision of 1½ to 2 cms length, a longer incision being taken in an obese patient. The upper skin flap is grasped with the small Allis forceps and retracted upwards and the lower flap is retracted down using a small retractor. The subcutaneous tissue is dissected from the umbilicus and the rectus sheath. The rectus sheath is grasped with another Allis forceps in the midline and two stay sutures are taken, on either side. With traction on the stay sutures, a vertical incision is made in the rectus sheath. A mosquito forceps is used to separate the rectus muscles and the peritoneum is grasped and held up in two mosquitoes. A very small incision is made in the peritoneum and after making sure that no other tissue is being injured this incision is increased and a blunt trocar- cannula to prevent any gas leak.

Carbon dioxide gas insufflation is then started. This can be done more rapidly and time lost in dissection is made up. It is also possible to take a purse-string suture around the peritoneal incision instead of the stay sutures, and tie it around the introduced trocar. At the end of the surgery, fascial closure is facilitated by the fact that the introduced trocar. At the end of the surgery, facial closure is facilitated by the fact that the rectus sheath was dissected well earlier, and also because the incision tends to be slightly bigger. Cosmetic results have been almost the same as that with the use of Veress needle and sharp trocar, though the incision is about ½ cm bigger.

It is important to note that whatever the experience of the surgeon may be, the safety of blind introduction of the Veress needle and the trocar cannot be ensured as much as with open laparoscopy.

Reference:

1 Ahmad G, Duffy JM, Phillips K, Watson A. Laparoscopic entry techniques. Cochrane Database Syst Rev.2008(2):CD006583.

2 Hasson HM. A modified instrument and method for laparoscopy. Am J ObstetGynecol1971;110(6):886-887.

3 Trocars: safety and selection. Emergency Care Research Institute. Health Devices.1998;27(11):376-399.

4 Hasson HM, Rotman C, Rana N, Kumari NA. Open laparoscopy: 29-year experience. ObstetGynecol 2000;96(5 Pt 1):763-766.

5 Mac Cordick C, LecuruF, Rizk E, et al. Morbidity in laparoscopic gynecological surgery: results of a prospective single-center study. Surg Endosc1999;13(1):57-61.

6 YuzpeAA. Pneumoperitoneum needle and trocar injuries in laparoscopy. A survey on possible contributing factors and prevention. J Reprod Med1990;35(5):485-490.

7 Corson SL, Chandler JG, Way LW. Survey of laparoscopic entry injuries provoking litigation. J Am Assoc GynecolLaparosc 2001;8(3):341-347.

8 Chapron CM, Pierre F, Lacroix S, Querleu D, Lansac J, Dubuisson JB. Major vascular injuries during gynecologic laparoscopy. J Am Coll Surg1997;185(5):461-

465.
9 Champault G, Cazacu F, TaffinderN. Serious trocar accidents in laparoscopic surgery: a French survey of 103,852 operations. Surg Laparosc Endosc1996;6(5):367-370.
10 Nezhat C. Operative Gynecologic Laparoscopy: Principles and Techniques. New York: McGraw-Hill,1995:79-96.
11 Brill AI, Nezhat F, Nezhat CH, Nezhat C. The incidence of adhesions after prior laparotomy: a laparoscopic appraisal. ObstetGynecol1995;85(2):269-272.
12 Yin L, Witten C, Neidelman S. Letter to manufacturers of laparoscopic trocars. In: FDA, Center for Devices and Radiological Health, Rockville, MD, Aug 23,1996.
13 Bonjer HJ, Hazebroek EJ, Kazemier G, et al. Open versus closed establishment of pneumoperitoneum in laparoscopic surgery. Br J Surg1997;84(5):599-602.
14 Larobina M, Nottle P. Complete evidence regarding major vascular injuries during laparoscopic access. Surg LaparoscEndoscPercutanTech2005;15(3):119-123.
15 Pasic RP, Kantardzic M, Templeman C, Levine RL. Insufflation techniques in gynecologic laparoscopy. Surg LaparoscEndoscPercutanTech 2006;16(1):18-23; discussion23-14.
16 Chapron C, Cravello L, Chopin N, et al. Complications during set-up procedures for laparoscopy in gynecology: open laparoscopy does not reduce the risk of major complications. Acta ObstetGynecol Scand2003;82(12):1125-1129.
17 Hanney RM, Carmalt HL, Merrett N, Tait N. Vascular injuries during laparoscopy associated with the Hasson technique. J Am Coll Surg 1999;188(3):337-338.
18 Wherry DC, Marohn MR, Malanoski MP, et al. An external audit of laparoscopic cholecystectomy in the steady state performed in medical treatment facilities of the Department of Defense. Ann Surg1996;224(2):145-154.
A consensus document concerning laparoscopic entry techniques: Middlesbrough, March 19 - 20 1999.Gynaecol Endosc 1999; 8(6):403-406.
19 Ballem RV, Rudomanski J. Techniques ofpneumoperitoneum.
Surg LaparoscEndosc 1993;3(1):42-43.
20 Hurd WW, Randolph JF, Jr., Holmberg RA, et al. Open laparoscopy without special instruments orsutures.
Comparison with a closed technique. J Reprod Med 1994;39(5):393-397.
21 Perone N. Laparoscopy using a simplified open technique. A review of 585 cases. J Reprod Med1992;37(11):921-924.
22 Gordon S, Maher P, Seman E. Open laparoscopy utilizing either a 5 mm or 10 mm standard intra-umbilical trocar. GynaecolEndosc2001;10(4):249-252.

Chapter 7

PROPER MAINTENANCE OF INSTRUMENTS

INTRODUCTION

Instruments represent a significant material asset within the overall investment of a hospital. The practical experience mentioned here is combined with a description of fundamental relationships and is intended to help preserve the functional capability and value of the instruments over many years through correct care and maintenance. The recommended measures must be implemented in compliance with hygiene requirements.

This article includes instructions for the preparation of elastic rubber and plastic instruments as well as for the surgical motor line. Detailed information is given regarding steel materials for instruments, the required quality of water and further recommendations for the proper handling of instruments.

The requirements for the various types of steel are based on national and international standards (DIN and ISO) with special consideration of the specific functional characteristics and demands for the use of surgical instruments.

When inquiring about the meaning of terms like “high-grade steel” or “stainless steel” very often the assumption is that high-grade steel is an indestructible, extremely resistant material. Even in hospitals, numerous users expect that instruments of high-grade steel have to be everlasting. They are surprised if they are told, or find out for themselves, that even high-grade steel can be susceptible to many different kinds of mechanical, thermal or chemical attacks.

Understanding the material and its characteristics, together with knowledge regarding correct handling, will result in achieving trouble-free, long-lasting use of high- grade steel instruments.

Only a very limited number of stainless steel type scan satisfy the requirements asked for by the user of surgical instruments. Due to their special alloy, high-grade steels used for surgical instruments are characterized by the fact that they form specific passive layers as a protection against corrosion. These protective layers can, however, be damaged by external influences which will harm the instruments. Only to a limited extent are high-grade steels resistant to the attack of aggressive waters, e.g. with a high chloride content. In particular, chloride ions can cause pitting or even stress corrosion cracking.

Users of surgical instruments can be assured that manufacturers take great care not only regarding the selection of the correct steel types but also regarding the steel processing. To maintain the value of the instruments, the user must provide continuous expert care and correct preparation.

Instruments for microsurgery and laparoscopy require especially careful preparation.

These instruments are very delicate and have extremely fine elements for operating reasons. Therefore they are extremely sensitive to improper mechanical strain when in use, preparation or transportation. It has also been proved that in most cases, damage can be traced back to mechanical influences – and mostly, such damage is irreparable.

Components which do not have to be sterilized, such as columns, foot switches, cables etc. are not discussed here. Special instructions for the preparation and treatment of MIS-instruments, flexible and rigid endoscopes are also given.

The working group for hospital hygiene recommends. “In the interest of patience safety, the hygienic requirements for endoscopic surgery should be the same as in conventional surgery. Thoroughly cleaned and sterile instruments are allowed for use in endoscopic surgery. This assures that an important part of quality assurance requirements are met”.

MIS-instruments, which are used with pressure (gas insufflation) during an operation, soil heavily. Therefore they need special attention for cleaning: Either they can be dismantled or they can be rinsed through a channel.

Endoscopes are precision instruments for observation of an illuminated preformed body cavity or body opening (e.g. bladder, intestine, abdominal cavity, bronchi, joint cavities, vessels). As a result of the various endoscope designs, different materials are used for their production, the different characteristics of which must be taken into consideration.

Single-use instruments should be fundamentally used only once! Therefore no additional comments on reprocessing single-use instruments is discussed.

Elastic instruments of rubber or plastic, as used for example in urology, anaesthesia or gastroenterology, also require special preparation methods.

Recommendations for the preparation and treatment of breathing systems refer only to those parts conducting gases, such as:

- Breathing tubes
- breathing bags
- breathing masks
- folding bellows
- connection pieces

Maintanence of instruments involes:

1. Meticulous cleaning
2. Decontamination
3. Disinfection
4. Sterilization

Cleaning is defined as the Removal of visible dirt, soil, organic matter or other foreign material. It is a removal rather than a killing of micro organisms.

May be accomplished with

- Water
- Mechanical action
- Detergents
- Enzymatic products

Importance of Cleaning
(1) Renders disinfection or sterilization effective.
(2) Brings about a 4 log reduction in contaminating organisms

Decontamination is defined as a Process both Physical and Chemical or either, to remove or reduce contamination from infectious organisms or other harmful substances
Cleaning and Decontamination may be
(a) Manual
(b) Automatic washer/decontaminator- which is safer to personal, but is not easily available, and cannot be used for some instruments.
Enzymatic Products are Catalysts that enhance or loosen dried or hard to remove debris. Usually added to water or cleaning solutions

Preparation for disinfection and cleaning
Disinfection of soiled instruments not only helps to preserve the instruments themselves, but also serves to protect those persons responsible for their transportation and cleaning. The guidelines of the Robert-Koch-Institute state: "Wherever possible, instruments should be disinfected and cleaned immediately after use. Any soil left to dry will make eventual cleaning much more difficult and could result in damage to the instruments. If necessary, instruments should be taken apart, allowing the disinfectant to cover all surfaces."

Personal Protective Attire

1. Scrub suits under a moisture impervious gown or important suit
2. A Mask and goggles/full face shield – protection form splashes or aerosolization
3. Heavy duty long cuffed gloves
4. Isolate the cleaning area from rest of the operating room.

Selection of a cleaner/Detergent

1. Detergents should Facilitate loosening of Debris and not damage Instruments – Enzymatic cleaners are best
2. Should rinse of without residues
3. PH<7 – best for inorganic debris such as urine hard water scale
4. PH>7 – organic soil such as blood, faeces
   Stainless steel instruments
5. Follow manufactures instructions at all times

Topical antimicrobials intended for skin antisepsis is not to be used for disinfection of the instruments either moist heat or chemical disinfection can be used. Moist heat is preferable, providing the instruments are suitable for treatment in this manner. Unused instruments have to be prepared in the same way as used instruments;

therefore those instruments have to be opened or dismantled.

Occasionally, corrosive caustic agents and medicines (e.g., silver nitrate, iodine preparations, albotyl and mercury components) are used in operations and for medical treatment. Remnants of these substances have to be removed immediately.

Under no circumstances must instruments be stored in physiological saline solution as prolonged contact causes pitting and rust.

Undue "dropping" can cause damage to the instrument. Hard metal tips on scissors may be chipped or small, delicate clamps can be deformed. In order to avoid this, carefully handle and deposit the instruments after use.

To avoid encrustation and corrosion, return in dry condition and to CSSD, the instruments must immediately be subject to machine treatment. Therefore "dry" has to be taken word-to-word. Even small amounts of fluids (e.g. dishes with physiological saline solution) should be avoided on the goods for return.

For this treatment, deposit the instruments on suitable trays, e.g. perforated sterilizing trays. For effective cleaning, hinged instruments have to be opened (such as scissors, clamps, gouge forceps).

For return in wet condition to CSSD, instruments have to be immersed into a combined disinfecting and cleaning agent. Therefore use only non-corrosive agents in prescribed concentrations. Water alone is not sufficient.

Instruments should never be left overnight before cleaning as the risk of causing permanent damage increases with the length of time between use and preparation.

Handles and cables for HF-surgery have to be prepared like surgical instruments.

Dismantled tubing sets for cooling liquid and spray nozzles have to be rinsed immediately with water from the rinsing bottle and checked for leakage

MIS-instruments and rigid endoscopes have to be dismantled according to the manufacturer's instructions. This equipment has to be placed in special containers designed for this type of equipment.

Articles which are declared "for single use only" have to be disposed.

Dried residues are crucial, especially for operative endoscopy, because of the difficulty of removal in small lumens and may lead to dysfunction of the links. Therefore these instruments have to be processed immediately after use. It is recommended to use a 3% solution of hydrogen peroxide for rinsing the HF-instruments to remove the coagulated tissues that may form during longer operations.

Instruments should be transported in special containers or retaining devices to avoid damage to the instruments.

Dismantle elastic instruments and breathing systems according to the manufacturer's instructions. Cones, sealing surfaces, thread connections and valve plates have to be carefully handled and protected against mechanical damage.

Prior to preparation, completely remove breathing lime from the absorbers. Data readers have to be prepared only according to the manufacturer's instructions.

1. Manual disinfecting and cleaning

For manual preparation, instruments have to be immersed into a combined disinfecting and cleaning solution with proven disinfecting effect.

The instructions of the manufacturer have to be strictly followed regarding concentration, temperature and exposure time. Special attention has to be paid to the manufacturer's instructions with regard to material compatibility of instruments not made of high-grade steel.

Use fresh disinfecting and cleaning solutions every day. The following problems may occur due to using the same solution for too long:

- risk of corrosion due to soiling
- risk of corrosion due to increasing
- decrease of disinfecting effect due to excessive dirt concentration

Instruments with a narrow lumen (tubings, cannulae) or with cavities are generally difficult to prepare. One must, therefore, take care that the passages are free and that the inside is completely in contact with the solution.

If powdered products are used, completely dissolve the powder first. Only then should one immerse the instruments since un dissolved particles may lead to clogging of the narrow lumen and discoloration of the instruments.

After chemical disinfection and cleaning, the instruments must always be rinsed well under running water. Rubber and elastic plastic needs longer rinsing time than other materials. Any remaining residue have to be removed manually with minimal trauma to the instruments (no metal brushes, no scouring agents!). In order to avoid water spots, a final rinse with demineralized water is recommended. Finally, the instruments have to be dried immediately.

Water on the surfaces of elastic instruments made of rubber or plastic may cause white spots to appear which can only be removed by drying.

If, after manual cleaning, instruments are chemically disinfected instead of being sterilized, a separate disinfectant has to be used.

The instruments must then be rinsed thoroughly with sterile demineralized water and dried immediately.

If pneumatic air is used for drying, make sure that the air flows through a sterile filter.

Simple tools can be prepared like surgical instruments.

MIS-instruments and rigid endoscopes have cavities and channels which are difficult to clean. Careful preparation of these instruments requires:

- Removing the seals/washers
- Opening the stop cocks
- Dismantling according to the manufacturer's instructions

Use brushes with plastic bristles, cleaning guns or clean soft cloths to avoid damage due to unsuitable cleaning accessories. Drying with compressed air is very gentle and effective, and therefore it is the preferred method of drying. When immersing the endoscope into the cleaning and disinfection solutions, make sure that all air bubbles escape from the cavities by moving the instrument, or by holding it in a sloped position, thus guaranteeing complete wetting of the surface.

Use a wooden applicator with cotton wool soaked in alcohol to gently rub off any dirt on windows or glass surfaces, otherwise use a neutral detergent (hand washing liquid).

MIS-instruments and rigid endoscopes with encrustation which could not be removed through intensive cleaning (e.g. brushing, ultrasonic treatment) have to be discarded because it is not possible to ensure the function of the device.

Comment:
Instruments which cannot be dismantled and have a rinsing connection should be rinsed thoroughly with a cleaning-/disinfection agent. Observe the distal end to ensure that the fluid is flowing out.

Elastic instruments with lockable cavities, such as bellows and breathing masks have to be cleaned and disinfected in closed condition thus avoiding the penetration of liquid into the cavities.

To avoid damage on diaphragms and functional parts of the breathing system, no compressed air should be used for cleaning.

2. Machine Disinfection and cleaning

The instruments should preferably be returned in dry condition to the machine preparation. At the return in wet condition the danger of protein-fixation exists from several chemicals. Therefore use a disinfectant with a cleaning component. These agents should be either low-foam producing disinfectant or else the instruments have to be thoroughly prewashed as foam development in the cleaning and disinfecting machine can reduce the cleaning results. This comment also applied to instruments with problem encrustation (encrustation by HF-instruments, remnants of filling materials or similarities) that have been pre-treated with or without ultrasonic.

The disinfection of instruments in a cleaning and disinfection machine is preferably done thermally at a set temperature and time (e.g.93^{o}C/10minutes). The methods of

cleaning and thermal disinfection are distinguished between epidemic-hygiene aspects and general-hygiene aspects.

Chemo thermal procedures are used for thermolabile instruments or material.

Methods under epidemic-hygiene aspects require the disinfection in the first phase. Alkaline detergents are preferably used for cleaning. Methods under general-hygiene aspects require separate phases: first the cleaning and later the disinfection. As detergents pH-neutral and/or enzymatic products are preferred. In both cases detergent and program have to be tuned.

A good cleaning during the instrument preparation helps to maintain the value of the instrument. Therefore methods are preferred which are optimized for cleaning and which run the cleaning separately from the disinfection in the content of a general infection prophylaxis.

When using cleaning agents, and if necessary, disinfection agents, it is recommended to strictly follow the instructions of the manufacturer regarding exposure time, concentration and temperature. Using the correct concentration does not only guarantee a perfect disinfection and cleaning result, but also the most careful treatment of the material. Automated fluid dosing have to be supervised. In the presence of increased chloride concentrations in water, pitting can occur on the instruments. Such corrosion can be avoided through using alkaline products during the cleaning phase and de mineralized water for the final rising.

The inflowing water for the cleaning phase should be cold prior to beginning the main cleaning phase. Warm water, especially with temperatures over 45^{o}C, will lead to coagulation of proteins and therefore lead to cleaning problems.

With machine cleaning, special attention has to be paid to the following:

- Trays and machine must be correctly loaded
- Hinged instruments have to be opened, thus guaranteeing thorough cleaning in the joint.
- Do not overload the perforated trays, so that all instruments can be well rinsed.
- Place large and bulky instruments properly on the trays thus avoiding “shadows” on other instruments.
- A thorough internal flow has to be guaranteed with instruments having long, narrow cavities (tubing, cannulae, breathing systems). Use special inserts with rinsing-devices which are designed for the instruments.
- Place instruments depending on their mechanical construction in such a way that they cannot damage each other.
- Colour-anodized aluminum instruments may lose their colour and their coding function if normal machine preparation methods are used. It is possible to clean colour- anodized instruments together with the other instruments by using pH-neutral detergents at lower temperatures and demineralized water for the final rinse (also for the thermal disinfection).

Residues from the cleaning phase have to be totally removed in the subsequent rinsing procedures, otherwise spotting and/or discolouration may occur. Additional use of a suitable neutralizing agent improves the rinsing results especially with alkaline detergents.

Should corrosion occur on surgical instruments due to bad water quality, then the rinsing temperature should be limited to70-75^{O}C for thermal procedures under epidemic- hygiene procedures the final rinsing on thermal disinfection should be demineralized water. When using demineralized water for final rinsing then corrosion, water spots and also discolourations depending on the reasons will be avoided. No temperature limit must then be observed.

If the drying of the machine is not sufficient then dry the instruments manually.

MIS-instruments and rigid endoscopes have to be dismantled for machine preparation according to the manufacturer's instructions. Seals/washers have to be removed and stopcocks opened.

Machine preparation should be done only if recommended by the manufacturer. In order to avoid damage, secure the parts safely. The maintenance by machine is only allowed with a machine which is proved to be a cleaning and disinfection machine for this usage. The machine must thoroughly flush inside any instrument lumen.

Instruments with encrustation of coagulation which could not be removed through intensive cleaning (e.g. brushing, ultrasonic treatment) have to be discarded because it is not possible to ensure the functionality of the instrument or that sterilization will be effective.

Elastic instruments with lockable cavities, such as bellows, breathing masks etc., have to be cleaned and disinfected in closed condition thus avoiding the penetration of liquid into the cavities. To avoid over- stretching of the edge of the mask, remove the nipple prior to preparation, press out some air and replace the nipple.

Elastic instruments, made of PVC for example, with low temperature resistance have to be disinfected, cleaned and dried at max.65^{O}C.

Care has to be taken with rubber instruments because residues of cleaning agents lead to irreversible damage by subsequent drying and sterilization. The surface of the material depolymerizes and gets sticky. Latex-coating dissolves under blistering.

Especially serious are residues not completely flushed out of functional parts of the breathing system. Furthermore, all parts have to be completely dry as remnants of moisture may lead to functional troubles.

Elastic instruments may not be dried above 95^{O}C; higher temperatures considerably shorten their life span.

Functional parts of breathing systems are specially designed by the manufacturers of ether units. Preparation can, therefore, only be performed according to the

manufacturer's instructions.

3. Ultrasonic treatment

Ultrasonic treatment is particularly suitable for cleaning instruments of high-grade steel. Delicate instruments (microsurgical instruments, dental instruments) can be carefully and thoroughly cleaned by ultrasonic treatment. Powerful machines for ultrasonic treatment are able to remove encrustation in inaccessible places.

Ultrasonic treatment is used for:

- Effective mechanical help for the manual cleaning processes
- For pre-treatment of instruments with encrustation that is dried on before machine cleaning and disinfection
- In special designed component parts for tunnel washers which can be ordered optionally
- In order to achieve optimum efficiency of the ultrasonic treatment, please observe the following.
- Fill the bath following the instructions by the manufacturer
- Add a suitable cleaning agent or a combined cleaning and disinfecting agent,
- When using disinfecting and cleaning agents, make sure that the concentration, temperature and time of sonication recommended by the manufacture are correctly maintained
- It is advised to fill the bath with warm water because temperatures over $40^{O}C$ promote degassing and cleaning.

Even with a properly prepared bath, faults can arise. These can be avoided by observing some principle rules:

- Instruments have to be completely covered by the cleaning solution. Non-immersed instruments will not be cleaned.
- Hinged instruments, e.g. scissors, have to be opened.
- Only trays which do not affect the ultrasonic treatment should be used (e.g. trays made of wire)
- Large and bulky instruments such as lead hands or kidney trays must be placed in such a way that there are no wave shadows or inactive zones. Place such items either vertically or put them on top of the other instruments.
- Trays may not be overloaded,
- An excessively dirty solution in the ultrasonic bath decreases the cleaning effectiveness and increases the risk of corrosion. Depending on the frequency of use, the solution has to be renewed at regular intervals.
- Ultrasonic treatment times of approx. 3 minutes have proved to be efficient for cleaning at frequencies of at least 35kHZ.
- In the case of simultaneous disinfection and cleaning, suitable products should be used paying attention to exposure concentration and time.
- After ultrasonic treatment, the instruments have to be thoroughly rinsed either manually or by machine. Rinsing has to be performed with clear water of at least potable water quality or, better still, with demineralized water in order to avoid water spots.
- The instruments should then be thoroughly dried.
- To avoid damage, micro-surgical instruments have to be deposited on special racks.

- Ultrasonic treatment is only allowed for those parts of MIS-instruments or rigid endoscopes which are suitable for this procedure according to the manufacturer's instructions (e.g. no optical systems).

- MIS-instruments and rigid endoscopes with coagulated encrustations caused by using HF- treatment and could not be removed through intensive cleaning have to be discarded because it is not possible to ensure the functionality.

- Elastic instruments are not suitable for ultrasonic treatment as ultrasonic waves have no effect on elastic surfaces.

- Functional parts of the breathing system can also not be prepared in an ultrasonic bath.

Care and maintenance

Instruments with joints or ratchets have to be treated with a suitable autoclavable lubricating agent during the cleaning process.

These lubricating agents prevent the friction of metal on metal and preserve smooth function of the instruments thus avoiding corrosion by friction. Furthermore, constant use of such agents prevents "sticking" of the hinged parts.

The lubricating agents can either be applied manually or during the final rinsing in the machine.

In any case, it is indispensable that threads, joints, etc. that are difficult to access are directly treated with each preparation.

MIS-instruments and rigid endoscopes contain different materials like plastic or rubber that may be affected by the lubricant. In general, lubricating agents applied (by machine or manually) to optics, seals and current-carrying parts can lead to massive troubles and dysfunction and therefore should not be done. This includes instrument milk.

Joints, threads, sliding surfaces and non maintenance-free stop cocks may have to be treated with special oil or special grease according to the manufacturer's instructions.

The only necessary maintenance on flexible endoscopes is to treat the valves with silicon oil before inserting them into the valve housing. Do not spray them with care agents as the propellent gases will damage the instruments.

Only silicon oils and grease-free gels should be used as lubricants according to the manufacturer. Agents containing Vaseline or paraffin cause swelling or softening of rubber parts.

Refrain from treating elastic instruments and breathing systems with lubricants prior

to sterilization. Special care and maintenance measure are prescribed by the manufacturer, should the need arise.

Elastic instruments of silicon rubber may not be treated with silicon because of swelling which makes them inoperable. Under no circumstances use paraffin agents for rubber and latex instruments; this prevents them from swelling up.

Inspection

Each surgical instrument is designed for a specific purpose. Inspection has to be carried out to ensure that they still function as they should. If in any doubt, a reliable manufacturer can advise you on suitable inspection methods.

After each cleaning, the instruments have to be macroscopically clean, i.e. free of visible protein remnants and other contamination.

Prior to functional inspection, surgical instruments with movable parts should be cooled down thus avoiding metal friction leading to corrosion. Before carrying out functional inspection, oil any instruments with joints, ratchets or threads.

Instruments with non-traumatic toothing have to be specially inspected, and, if necessary, the non- traumatic toothing cleaned manually to keep the non- traumatic function.

Worn out or damaged instruments should be removed for repair or replacement. Corroded instruments should be discarded immediately as these can cause contact corrosion even on a perfect surgical instrument.

Especially fine and delicate instruments are inspected under the magnifying glass. In order to avoid damage during transportation, place the instruments in specially designed racks or use special holding devices to prevent them from slipping.

Faultless surgical instruments should not be packed together with instruments having damaged surfaces. Older instruments with chipped chromium and/or nickel coating may cause discoloration or corrosion on high-grade surgical instruments. It is, therefore, recommended to discard such instruments or pack them separately.

Handles, cables and cables for neutral electrodes for HF-surgery have to be checked for faultless function.

(Caution: defective contact). It is compulsory to sort out defective parts.

Instruments given to repair have to be completely decontaminated due to hygienic reasons.

Stains on instruments are due to improper preparation. Because stains are usually found during inspection, the reasons here of are discussed now. Cause of such stains or spots can be:

- Insufficient mechanical or manual cleaning.

- Unsuitable cleaning, disinfecting and care agents.
- Failure to observe the dosage instructions for cleaning, disinfecting or care agents.
- Residues of cleaning and disinfecting agents – insufficient rinsing.
- Poor water quality.
- Water-soluble residues e.g. washing agent in textile cloths for warpping,
- Residues in the sterilizing steam (exceeding the index for contaminants in steam)
- Remanants of medications, marking pens or chemo- indicators.
- Procedural faults e.g. not cleaning brand-new surgical instruments prior to sterilization.

These and other causes for spots on surgical instruments show the complexity and difficulty of the problems dealt with here. To facilitate tracing and identifying the cause for such stains, it is recommended to cooperate with competent manufacturers. By making useof the company's service, you will not only take advantage of their practical experience but their well-equipped laboratories as well.

To avoid permanent damage, instruments with residues on the surface have to undergo a special treatment. The method of treatment depends on the cause of the stains. In order to avoid damage and subsequent corrosion due to metal friction, under no circumstances use metal brushes or metal sponges to remove stains.

Prior to sterilization, the surgical motor line with accessories should undergo a functional inspection according to the manufacturer's instructions.

Simple tools are inspected as general surgical instruments. In order to avoid damage during transportation, store the tools in special racks or place them in suitable holding devices to prevent them from slipping.

The leak test for tubing sets for cooling liquid can be carried out by means of a clamp and a large syringe filled with water. Fill the tubing with water; close one end with the clamp, and insert and empty the filled syringe in to the other end.

The perfect function of MIS-instruments and rigid endoscopes can be ensured only through an intensive functional inspection. All dismantled instruments have to be assembled together following the instructions of the manufacturer prior to functional inspection.

Exchange or renew working parts and damaged components before sterilization. Especially test insulation for damage.

Instruments with encrustation of coagulation on working parts, which still exist in spite of cleaning, have to undergo a special manual treatment as described. If this does not help, then discard the instruments, endoscopes and accessories and replace them with new ones.

To avoid damage to optical systems, clean them carefully with a cotton swab moistened with alcohol. If this does not remove clouding on the optics, return the part to the manufacturer for inspection. Damage can be avoided by using wooden or

plastic handled applicators; metal is not suitable.

Light carrier in telescopes and fibre optic cables have to be checked for optical fibre breaks. To do this, take one end of the fibre optic cable, hold it against the light and look into the other end. Little black spots indicate breaks in the fibres. A large number of breaks reduces the light output. Such fibre optics as well as endoscopes with surface damage and surface deformation should be sent for repair.

Breathing systems have to be inspected according to the manufacturer's instructions.

Elastic instruments have to be inspected according to their function and range of use. The most important inspections are:

- Bellows have to be undamaged and airtight
- Filling system of the bellows must not show any leakage
- Lumina of catheters and probes have to be free
- Connections have to meet functional safety
- There should be no changes of design, e.g. radius of curvature of tracheal tubes

Elastic instruments with faults or damage have to be replaced.
Frequent problems are

- Detachment (blister forming)
- Cracked surface
- Sticky surface
- Hardenings
- Porous surface
- Discolouration

To prevent premature failure, take care that elastic instruments are stored in a dry place without being kinked or overstretched.

DISINFECTION

Disinfection – Process that eliminates many or all pathogenic microorganisms with the exception of bacterial spores from inanimate objects and surfaces.
Sterilization – destroys all microbial life

Factors affecting disinfections are:

1. Previous cleaning of objects
2. Type and level of microbial contamination
3. Concentration and exposure time to germicide
4. Physical configurations of the object [E.g., contains crevices, hinges and bureaus]
5. Temperature and PH of disinfecting process

SUSCEPTIBILY IN DECREASING ORDER

- Bacterial spores(Bacillus subtilis, Clostridium)
- Mycobacterium (Mycobacterium Tuberculosis)
- Non-Lipid or small viruses (Poliovirus, Rhinovirus)
- Fungi (Cryptosporidium, candida)

- Vegetative Bacteria (Staphycocus, Pseudomonas, eterococi, MRSA,
- Lipid or medium sized viruses (Hepatitis B, HCV, HIV, HS, CMV, RSV)

Classification of Patient care Items

Spaulding classification (1968)

- Nature of items.
- Manner in which used
- Degree of risk of infection

Critical items.

- High risk of infection if contaminated
- Enter sterile tissue or vascular systems or have blood flowing through them
- Sterilization is required.

Ex: surgical instruments
Implants
Needles
Endoscope accessories
Catheters—vascular\ Urinary
Laparoscopes

Semi critical Items

Contact with mucous membranes and Non-intact skin minimally receive high level disinfection (HLD). May also be sterilized. Some semi critical items such as Hydrotherapy tanks thermometers require only intermediate level disinfection. Examples: Endotracheal tubes, Endoscopes, Bronchoscopes, Laryngoscopes, respiratory and reusable anesthesia equipment, dializers, transducers, thermometer, hydro therapy tanks.

Non-Critical Items

Come in content with intact skin should receive intermediate or low level disinfection.
Eg: Stethescopes, blood pressure tourniquet cuffs, Echo leads, bed pans linens environmental surfaces as table tops, beside stands furniture floors etc.

LEVELS OF DISINFECTION:

High-level disinfections (HLD)

1. Eliminates all microorganisms except large population of bacterial spores
2. Achieved by immersing for specified period in a chemical agent –
   a)disinfection
   b) Steriliant
3. Some high level disinfectants with prolonged contact act as a steriliant.
4. Thermal HLD is accomplished with pasteurization

Intermediate Level Disinfection

1. Inactivates vegetative bacteria including micro bacteria, most viruses, fungi but not spores

2. Used for semi critical items
3. Achieved by immersing in specified chemical agent or by surface disinfection

Low-level disinfection

- Used on Non-critical items

Kills vegetative bacterial and some viruses and fungi but not tubercle bacilli
Accomplished by surface cleaning or disinfection by washing or cleaning with specific chemical agents

Chemical Agents -Germicide

Chemical used for HLD

- Exposure time = >-20 minutes 12 minutes for cidex OPA
- 2% - 3.4%Gluteraldehyde
- 0.08% - Peroxyacetic acid and 1%H2O2
- 7.5% hydrogen peroxide / 0.85% phosphoric acid
- 0.95% Gluteraldehyde / 1.64% phenol / phonate
- 0.2% perantic acid ((stasis20)
- 0.55% Orthophthaldehyde (Cider OPA as HLD only)
- Damand- Release chlorine dioxide (limited use)

ILD

- Exposure time = < 10minutes
- Ethyl or isopropyl / alcohol (70% -90%)
- Phenolic germicidal detergent solution
- Iodophor germicidal detergent solution
- Sodium hypo chloride (5.25% house hold bleach) 1:50 dilution

Low-level Disinfectants

- Exposure time = < 10minutes
- Ethyl or isopropyl /alcohol
- Phenolic germicidal detergent solution
- Iodophor germicidal detergent solution
- Sodium hypo chloride (5.25% base hold bleach) 1:500 dilution (100ppm)
- Quaternary Ammonium germicidal solution (disinfectant, not antiseptic concentration)

Disinfectant of HBV

- 2% Glutaradehyde : 0.55% orthophthalaldehyde
- Iodophor (80ppm)
- 70% Isopropylalcohol
- 80% Ethylalcohol
- 0.3% H2O2
- Sodium hypo chlorite 1:100 dilution

Disinfectants of HIV

- 2% Glutaradehyde : 0.5% orthophthalaldehyde
- 0.3% H2O2
- 50%Ethylalcohol
- Phenolics
- Sodium hypo chlorite 1:100dilution

Chemical High Level Disinfection

Important variant is contact time

If contact time of 10 hours is used a disinfectant may be used as steriliant

Factors influencing chemical agent include

- Organic load present on items to be disinfected
- Type and level of microbialcontamination
- Precleaning, rinsing, drying onitems
- Active ingredient of chemicalagent
- Concentration of chemicalagent
- Physical Configuration of the items (eg crevices,lumens)
- Exposure time of chemicalagent
- temperature and PH of the chemical agent
- Hardness of water
- Precense of surfactant

<u>Immersion Recommendations</u>

Items should be completely increased Lumens should be flushed with germicide Recommendation for immersion range from 12-45 minutes For HLD in 2% activated Gluteraldehyde is a minimum 20 minutes at 68% F (20`C) when used on meticulously cleaned instruments.

Vapor Exposure

Protective apparel for personal

Vapours are toxic therefore covered containers and adequate ventilation is necessary

Permissible exposure limit is 0.2 ppm per exposure

Automatal Reprocessing

AERs Standardize the disinfection process and decreased personal exposure to disinfectants. No currently available. AERs provide cleaning of endoscopes

Pasteurization

Pasteurization my be used for thermal HLD

It is suitable for HLD of some anesthesia equipment, respiratory therapy and other semicritical equipment

In a pasteurization – all items to be disinfected are exposed to a hot water bath, heated to 160`-180` F for a minimum of 30 minutes

It kills all microorganisms with exception of spores

Commonly used Disinfectants

Gluteraldehyde 2% solution

- Widely used easily available
- PH of 7.5 – 8.5
- Shelf life after activation is 14 days. Using a surfactant may increase shelf life
- Different contact times and different groups

1. 10 minutes – kills both gram +ve, -ve and viruses
2. 4 hours – sterilization including resistant spores
    - Protective gloves needed for personal to avoid allergies
    - It does not damage lensed equipment

(2Somes

Formaldehyde

Broad spectrum antimicrobial action only under optional conditions of

(a) Concentration
(b) Exposure time
© Relative humidity

At atmosphere pressure and temperature of 50`C it has limited spermicidal action

BoilingWater

Effective disinfection process

-Kills

1. Vegetative bacteria including M tuberculosis
2. Some viruses (including HBV and HIV)
3. Some spores

- Purpose designed water boiler is needed
- Hinged lid
- Perforated tray with rising / lowering level

Steriliztion

General

Sterilization conditions as well as units have to be in conformity with valid quality standards (EN-or DIN- standard).

Follow the sterilization instructions of the manufacturer.

Sterilization of accessories, as well as sterilizing packings, has to meet the requirements of both the instruments as well as the sterilizing method used.

Process that destroys all forms of microbial life – including spores on inanimate surfaces

Sterilization and sterity are absolute terms

Measured as a probability of sterility – sterility assured level (SAL)

Defined as Log 10 number of probability of survivor or a single SAL of 6 indicates 1in one million probability of a spore or microorganism's survival

Sterilization

1. Physical – dry and moist heat in a gravity/prevacum container

2. Chemical – Ethylene oxide, gas plasma, H_2O_2

Pre cleaning is also prerequisite of sterilization as for disinfections

Autoclaving

Normally, autoclaving is performed with saturated steam at 134^{O}. For articles with reduced thermal – stability a temperatureof 121^{O}C can be used at a longer time.

The sterilization procedure has to be standardized suitable for the goods to be sterilized. Sterilizing packings have to meet the valid standards with regard to quality and application of the packings and have also to be applicable to the procedure selected.

Steam used for sterilization has to be free from any contamination and should neither impede the process nor do damage to the sterilizer or the goods to be sterilized. In order to guarantee this, the limits for the quality of boiler feeding water as well as the condensate, should not be exceeded. Otherwise, contaminants such as rust particles from the conducting system may cause corrosion or a too high content of salicylic acid may lead to discolouration of the instruments.

Due to heating and cooling down during the sterilization process, a surgical instrument with a closed ratchet may suffer from tension stress which causes stress cracking in joints or deterioration of the clamping force. Therefore, such instruments have to be sterilized either in open condition or closed on the first ratchet only.

The loading weight of perforated trays filed with instruments should not exceed 10kg. By this way excessive condensate production during sterilization is avoided. Drying is facilitated by wrapping the perforated trays with a cloth within the container or external paper packing.

If heavy sets are unavoidable, the instruments should be distributed among several perforated trays. In addition, special measures may be necessary for drying.

After sterilization, instruments have to be stored dry until used again. Instruments as well as the inner covering of sterilized goods have to be absolutely dry after having cooled down to room temperature.

All components of the surgical motor line, meant for sterileapplication, can be autoclaved at 134^{O}C. Refer to the manufacturer's instructions. Special instructions of the manufacturer have to be observed for storage during sterilization.

Hoses for compressed-air have to be protected against pressing during sterilization.

MIS-instruments and rigid endoscopes can be sterilized by conventional methods in suitable packing. Optical systems suitable for autoclaving should be processed at 134^{O}C instead of at 121^{O}C due to the shorter thermal stressing. To avoid damage of optical systems by sterilization, they should be stored carefully following the instructions of the manufacturer.

Elastic instruments with and without bellows made of silicon and natural latex are

suitable for autoclaving. Dueto the shorter thermal stress, preference is given to a processing at 134^{o}C. Items of thermo plastic materials (plastic) may only be autoclaved if recommended by the manufacturer.

When elastic instruments are autoclaved, take care that the cavities, e.g. edge of mask, bellows, are open in order to avoid damage due to changes in pressure. Prior to sterilization, cavities closed with a valve (e.g. bellow catheters) have to be suctioned free of air and water by means of a syringe.

Functional parts of breathing systems can be autoclaved at max.134^{o}C. Cavities must not be closed in order to avoid damage to the valves.

Dry heat Sterilisation

- Used for anhydrous oils, petroleum products, talcum powder which steam or ETO cannot penetrate
- May be used for instruments that cannot be disassembled
- Products in jars and Canister take long to sterilize
- Exposure times of 6-4 hours needed–
  1) it prostrates materials slowly & unevenly
  2) microorganism is destroyed slowly
  Minimum time – 6 minutes for unwrapped at 400`F (204`C), to 6 hours at 250`F (121`C)
- Instrument with delicate, sharp, cutting edges are sterilized like this

Low Temperature Sterilization

- Useful for temperature and moisture sensitive critical medical devices

1. Ethylene Oxide
2. Gas plasma systems
3. Sterns

EthyleneOxide

- Widely used
- temperature and moisture sensitive equipment is ETO sterilized
- Exposure time - > 2 hours of exposure time to ETO at 129`F (54`C) followed by aeration time of 12-14 hours at 55`C, PVC tubes require 24 hours aereation time
- Gas concentration and relative humidity as well as contact time and temperature, relative humidity of at least 35% - to < 85% is needed
- Items should be completely dry before insertion
- At completion the door has to be left open by 2 inches for 15 minutes
- And personal leave the room before unloading
- Chambers with combination of sterilizer and aeriator is removed only after aeriation
- ETO gas is vented outside before opening and removing instruments
- If absorbed on skin – burns or blisters are seen
- If inhaled –mucosal irritant
- Prolonged exposure cause chemical carcinogen effect

- Patients are affected by improperly aerated polyethylene, rubber or silicon
- ETO is mixed HCFC (hydro fluorocarbons in 1:9 ratio) as stabilizing agent

Hot-air sterilization
When surgical instruments are hot-air sterilized, please take care to load and operate the sterilizers properly. To ensure safe sterilization, the temperature should not be below180^{O}C but should also not exceed 200^{O}C as this may cause structural changes leading to irreversible damage, especially as far as microsurgical instruments are concerned. Instruments with parts of rubber, plastic or textile as well as plastic-coated instruments and handles for electrodes are not suitable for hot-air sterilization.

The general use of lubricating agents should be omitted prior to hot air sterilization with the exception of the joints and ratchets of surgical instruments. For this, use paraffin- oil according to the valid pharmacopoeia. Excess oil should be removed because of the occurrence of brown- discolorations due to thermal changes of the lubricating-oil.

MIS-instruments and rigid endoscopes are not suitable for hot-air sterilization because of the high temperatures.

Elastic instruments are not suitable for hot-air sterilization. Breathing systems are not suitable for hot-air sterilization.

Gas sterilization
Gas sterilization should only be used when no other method is suitable.

Motor components should only be gas sterilized when explicitly recommended by the manufacturer.

Optical systems of nonautoclavable rigid endoscopes may be gas sterilized, however, follow the instructions of the manufacturer.

Goods sterilized with ethylene oxide require sufficient aeration times before being used again. Depending on the goods sterilized and on available aeration

Elastic instruments of thermo-labile plastic are not autoclavable but can be gas sterilized if the manufacturer gives instructions about a suitable procedure.

Elastic instruments of rubber and functional parts of breathing systems do not have to be gas sterilized, because they can be steam sterilized.

Gas Plasma Systems

Consist of a single diffusion phase (Hydrogen Peroxide vapors) and plasma stage

Advantages–
no toxic residue, no aeration required, simple to operate and fast cycle time of 7 minute

Disadvantages –
does not penetrate lumens, inability to process paper, linen & liquids
Instrument placed in a chamber – 59% H2O2 is injected into it vaporized and allowed to diffuse throughout. Then radio frequency energy is allowed to create hydrogen peroxide plasma. At the end of it the chamber is retuned to atmosphere pressure and cycle is complete.

PARACETIC ACID (STERIS) SYSTEM

- Liquid immersion sterilization process that are fully automated
- 35% paracetic acid and an anti corrosive agent supplied in a single dose container. Container is penetrated as the door is closed.
- Temperature of 50`C to 55`C is maintained

Advantages –

- no toxic wastes given out
- Cycle time of 30 to 45 minutes is short

Disadvantages-

- small number of instruments is a cycle
- Used for immesible instruments only
- No long term sterile storage – called just in time sterilization
- Expensive

Gamma Ray Sterilization

- Irradiation with cobalt 60 – gamma rays – limited to industrial use only
- Industrial use for heat sensitive and moisture sensitive items

Microwave Sterilization

- Low-pressure steam with non ionizing radiation Ozone Gas Sterilization
- Sterilizes with oxidation
- It is corrosive to metals destroys natural rubber

Newer homologies

- Vapor phase paracetic acid
- Vaporized H_2O_2
- Gaseous chlorine di oxide
- Pulsed light

Treatment of brand-new instruments

Shipping-packing of brand-new instruments have to be removed and instruments have to be stored in dry rooms, open to air. Temperature fluctuations may otherwise lead to condensation within the plastic packing and thus corrosion.
Under no circumstances store instruments in cupboards or rooms where chemicals are kept which can produce corrosive vapors.

Prior to first use, brand-new instruments have to be prepared. First remove any protective caps or foils. Cleaning, rinsing, lubrication, inspection and sterilization have to be carried out according to the procedures previously described.

Prior to the first preparation, microsurgical instruments have to be placed in racks or holding devices to avoid damage.

Elastic instruments have to be kept in their original pacing and stored in a dry, cool and dark place. When ordering please keep in mind that in addition to wear through use, elastic instruments are prone to aging even when in storage.

Functional parts of the breathing system frequently contain valves or membranes which can get sticky when stored for a longer period. Such valves or membranes have to be tested and operated before being put to use.

Special information

By following these instructions properly, there is no difference in the preparation of instruments with a mirror finish or matte surfaces.

These instructions do not refer to disposable items.

Instruments and cables with optical waveguides can generally be prepared like surgical instruments, if the manufacturers have not given other instructions. Only hot- air sterilization and ultrasonic baths cannot be used.

Fibre-optic cables should not be bent, nor coiled too tightly.

Cables and handles for HF-surgery can be machine prepared and are autoclavable.

For all other preparation processes, refer to the instructions of the manufacturer.

Water for preparation

Instruments must have certain characteristics in order to fulfill their function (e.g. cutting ability of scissors, clamping force of clamps and forceps). Only a very limited number of steels meet these requirements.Unfavourable water composition can, therefore, have a detrimental effect on such steels. Consequently, the quality of water must be taken into account when planning the sanitary installations.
Ordinary water contains dissolved salts contained varies depending on the water purification process. Evaporation of water leaves residues of salty encrustations (lime). Of all water components, chlorides have to be regarded as the most potentially damaging because in higher concentrations they cause pitting on instruments.

The relationships between chloride content in the water and pitting are not predictable in some cases.

In general, the danger of chloride induced pitting rises with

- increasing chloride content

- increasing temperature
- decreasing pH-value
- longer induction time
- rougher instrument surface
- insufficient drying

Experience shows that with a chloride content upto approx.120mg /l (corresponding to 200mg / lNaCl = sodium chloride) the possibility of pitting is low but rises rapidly with increasing chloride content.

Low concentration of other components can cause brown, blue, grey-black or rainbow colored discolorations. Such discoloration can be caused by contact with the elements iron, copper, manganese, magnesium and silicon in the water. Generally, there is no corrosion. By immersing or rubbing the instruments with suitable products containing acid (follow the instructions of the manufacturer) such discoloration can be removed to a great extent. In addition to the natural water components, sometimes there are rust particles in the water. Almost always, such rust comes from corroded piping systems. When preparing the instruments, such rust particles deposit on the goods and cause rust spots (extraneous rust) followed by corrosion.

Make it a basic rule to use de mineralized water for final rinsing.

Even when using an ion exchanger for demineralization, tarnishing can occur due to penetration of salicic acid. The remedy is in-time regeneration of the exchanger – consult an expert.

Materials

When producing surgical, microsurgical and dental instruments, the manufacturer will use the materials most suitable for the purpose for which the instrument is intended.

In most cases, the demands for high elasticity and toughness, good cutting ability and high wear resistance together with best possible corrosion resistance can only be answered by using metal materials for surgical instruments. Therefore, first of all, stainless and hardenable chromium steels with a chromium content of approx. 13% are used. Instrument characteristics, such as a smooth and homogeneous surface, a matte or mirror finish, and a hardened condition can be achieved with steels. The user has to observe, however, that these instrument steels, listed in national (DIN) and international (ISO) Standards, are generally resistant to chemical and thermal stress as occurring in doctors' practices and hospitals, but are, onthe other hand, very sensitive to stress corrosion and chloride induced pitting.

Beside the hardenable stainless chromium steels, non hardenable chromium steels with modified chromium content and rust and acid resistant chromium nickel steels are used. The use of the latter steels is limited to certain instrument types due to restricted mechanical properties.

Due to the application technique and design of the endoscopes, the greatest variety of materials is used. Here are some of the most important ones:

- Rust and acid resistant chromium-nickel steels.
- Surface treated non-ferrous heavy metal alloy e.g. brass, chromium-nickel plated.
- Light metals (e.g. anodizedaluminium).
- Non-corrosion resistant steels, e.g. for lacquered modules and single parts.
- Glass for optical systems.
- Ceramic, Cement and adhesives.
- Plastic and rubber.

The combination of these heterogenous materials is, with regard to the preparation of the units, a weakness in the chain of materials. It may, therefore, be possible that special processing, deviating from the ordinary preparation processes, may become necessary. When in doubt, ask the manufacturer should he not have already given recommendations for use.

Elastic instruments and breathing systems also demand a wide variety of materials, similar to those used for endoscopes. i.e rubber, latex and silicon.

The full scale of materials dealt with in this brochure is used for the motorized surgical devices as far as design, structure and manufacturing is concerned. Stainless, hardenable chromium steels are used for burrs, drills, milling cutters, saw blades and gearing parts as well as sterilizable plastic material for handles, switches, gearing parts or cables and hoses.

Special preparation methods may be necessary for enameled housing of the unalloyed steel sheet, lacquered colour codes for identification of the gearing on hand pieces or anodized housings of aluminium for hand pieces and angular hand pieces. Heavily used flexible cables, bearings and gearing parts of stainless, but also of non- stainless heat-treatable steels as well as bronze materials require special preparation and lubrication methods.

Should any question or doubt arise, it is strongly recommended to ask the advice of the manufacturers.

Due to chemical or thermal influences during use, preparation or sterilization, all instruments and units, dealt with in this brochure, can experience surface changes, corrosion or aging.

Surface changes, corrosion and aging
Surface changes are visible appearances. Normally, this refers to all kinds of instruments and units, independent of the material. In particular, this refers to removable residues such as adhering or already encrusted residues from operations or other soilings. Through cleaning using special basic cleaning agents, such surface changes can be completely removed without doing any harm to the instruments.

Quite often, yellow-brown to dark-brown blister-like spots show on sterilized instruments and units made of metal and are mistaken as rust. In most cases, such residue can contain high degrees of chlorides which then lead to chloride induced pitting on parts made of stainless steel if the spots are not removed immediately. Such residues are usually found on those places with difficult access for cleaning.

Annealing colors, black tints or water spots appear mostly on metallic instruments and units and hardly ever on rubber or plastic products.

In general, discolorations do not show clearly defined edges. Flowing color shadings or deep and uniform staining (black colorings) can appear. Discoloration does not permanently damage or destroy the instruments or units. Causes can either be the bad quality of water used for cleaning or autoclaving as well as inadequate machine cleaning and installations for steam supply. The only remedy is to check the technical equipment in the house installation, in cooperation with the manufacturer of cleaning, sterilization and steam supply plants and also together with the manufacturer of disinfectants or cleaning agents.

Water spots are similar in appearance. However, normally they show sharply defined edges and are caused by too high a concentration of minerals e.g. lime or organic substances in rinsing water or sterilization steam.

The remedy is to use demineralized water for final rinsing and purified steam.

Overloaded sterilizing plants may cause increased condensation and consequently increased stains during sterilization – therefore avoid overloading.

The term corrosion refers to metallic material only.Corrosion is specific to materials and occurs on various metals in different appearances. Almost always the corrosion leads to permanent damage or even destruction of instruments and units.

Any kind of corrosion on surgical instruments and units can only occur due to contact with water, aqueous solutions or steam. Following is a description of the most important kinds of corrosion and their effect, in the sequence of their frequency of appearance.

Pitting corrosion refers only to metallic materials. Unfortunately, pitting can also appear on stainless steels of which not only most surgical instruments are made, but also endoscopes, (although fewer in number), surgical motor line and parts of breathing systems. With all types of steel, pitting is mainly caused by active chlorides (chloride induced pitting). Other halide ions (iodides, bromides) have the same effect. Nonferrous metals such as copper and aluminium alloys can also be damaged by pitting, however, other electrochemical causes may also be the reason.

Pitting means that holes have developed on thesurface of the instruments. These holes indicate rust and, with continuous corrosion, get rapidly bigger and destroy the instrument within a short time.

Pitting can only be avoided if instruments that have been in contact with chlorides or other halide ions are cleaned immediately after use. Please note that organic debris also contains chlorides which lead to pitting should these residues stay long enough on the instruments.

Attention also has to be paid to the quality of water used for cleaning and disinfection, especially with regardto its chloride content.

Stress corrosion cracking normally occurs only in steels used for surgical instruments; it can have considerable effects on the life span of the instruments.

The causes of this type of corrosion can lie either in the manufacturing process or in incorrect handling.

In order to avoid damage, it is absolutely necessary that during the complete cleaning phase, all instruments are kept in open condition.

In order to avoid damage such as stress cracks in the joint and a reduction of clamping force, when sterilizing such instruments, only close the first ratchet. This prevents stress forces from occurring while heating and cooling during the sterilizing process.

Even tiny quantities of chlorides in the water may favour the forming of stress corrosion cracking.

Fretting and crevice corrosion have almost similar causes. Both types of corrosion occur in narrow joints due to chemical or mechanical destruction of the natural passive coating of the high quality steel. In addition, due to lack of sufficient lubrication, metallic abrasion occurs in joint crevices and hinders smooth action of the instrument. In both cases, and together with humidity, rust blisters occur in the crevices.

Contact corrosion can occasionally be observed when surgical instruments are machine cleaned. Metallic contact of instruments and unfavourable cleaning and rinsing conditions, e.g. tap water containing chlorides, can cause rust.

Particularly severe contact corrosion occurs if stainless steel instruments get in contact with non-stainless goods, such as needles, cutters etc. Chromium-plated instruments with chipped surfaces also cause contact corrosion.

With surface corrosion, the total surface of a metal part is relatively uniformly attacked by chemical or other electrochemical influences. The surface can show parts which differ in color to undamaged surfaces.This corrosion takes the form of rust where steels are concerned.

Surface corrosion hardly ever occurs with instruments made of stainless steel.

Instruments, trays and containers of anodized aluminum require a preparation method suitable for the material. Acid or alkaline solutions may cause laminar corrosion which, especially on colored parts, causes “bleaching”.

Instruments and units of stainless steel or non-ferrous metal, protected by galvanically applied coatings, show surface corrosion only with damaged protective coatings.

Any kind of corrosion leads to rust on steels. Rust particles are transferred from one instrument to another during disinfection, cleaning or sterilization, so this transferred rust causes resultant corrosion on the second instrument. If corroding instruments

are not separated, further preparation processes promote rust formation on other instruments.

Sterilizing steam from rusty steam supply pipes may transport rust particles into the sterilizer. This extraneous rust deposits itself on the inside of the sterilizing chamber, on the packings, on instrument surfaces. This extraneous rust also leads to resultant corrosion on instruments.

Aging mainly refers to rubber and latex materials used for flexible instruments, such as parts of endoscopes and breathing systems. Aging is a slow going natural process occurring also during storing. The aging process is accelerated by the induction of dry heat with temperatures above80^{O}C, by stretching and over stretching when storing as well as by the action of light (e.g. sun light, UV beams). Aging is visible on rubber by discoloration (brownish) or brittleness (cracks on the surface). Plastic also ages: it gets hard and becomes yellow. However, silicon cautchouc, also called silicon elastomer, does not age.

Another result of aging on rubber, latex and plastic is the so-called swelling which is caused by the penetration of liquid or gases to the surface.

Swelling can be reversible and occurs only temporarily by the induction of volatile solutions or propelling gases of sprays. This also applies if rubber and certain plastic get into contact with ether gases such as halothane. Irreversible swelling, however, occurs by contact with non-volatile oils (paraffin), Vaseline and unsuitable disinfectants (e.g. phenol derivates). Silicon cautchouc reacts reversibly on propellent gases of sprays and ether gases; irreversibly on silicon oils and solvents.

Typical signs of swelling are soft sticky surfaces as well as damage to thin-walled instruments parts.

Reference:

1. Favero MS, Bond WW: Chemical disinfection of medical and surgical materials. In: Block SS, ed.: *Disinfection, Sterilization,andPreservation*,4thed.Philadelphia:Lea&Febiger, 1991. p.617–641.

2. RutalaW: APIC guideline for selection and use of disinfectants.*AmIInfectControl*.1900;18:99–117.

3. SpauldingEH:Chemicaldisinfectionofmedicaland surgical materials. In: Lawrence CA, BlockSS, eds. *Disinfection, Sterilization, and Preservation*. Philadelphia, Lea &Febiger, 1968. p. 517–531.

4. Vesley D, Norlien KG, Nelson B, et al. Significantfactors in the disinfection and sterilization offlexible endoscopes. *Am I Infect Control*. 1992; 20:291–300.

5. Phillips J, Hulka B, Hulka J, et al. Laparoscopic

procedures:TheAmericanAssociationofGynecologic Laparoscopists'membershipsurveyfor1975.*JReprodMed*. 1977;18:277–232.

6. RutalaWA, Clontz EP, Weber DJ, et al. Disinfection practicesforendoscopesandothersemicriticalitems.*Infect Control Hosp Epidemiol*. 1991;May:282–296.

7. Newman MA, Kachuba JB. Glutaraldehyde: A potential healthrisktonurses.*GastroentNursing*.1992;June:296– 301.

8. Centers for Disease Control: Symptoms ofirritation associated with exposure to glutaraldehyde— Colorado. *MMWR* 1987;36:190–191.

9. CrowS:Peraceticacidsterilization:Atimelydevelopment for a busy healthcare industry. *Infect Control Hosp Epidemiol*. 1992;13:2.

10. Steris Corporation. Steris system 1: Technicaldata monograph. Cleveland, OH,1988.

11. Wallace CG, DeMicco DD, Agee PM: Nosocomial pseudoinfection associated with endoscopy processor disinfection using 2% glutaraldehyde: Alternative 35% peraceticacidwithSterisSystem1.Abstractpresentedat the Third International Conference on Nosocomial Infections, Atlanta, GA,1990.

12. Marshburn PB, RutalaWA, Wannamaker NS, et al. Microbiological studies of gas and steam sterilization of assembledversusdisassembledlaparoscopicequipment.*J ReprodMed*. 1991; Jul;36(7):483–487.

13. LofferFD:Disinfectionvs.sterilizationofgynecologic laparoscopy equipment: The experience of the Phoenix SurgiCenter. *J ReprodMed*. 1980;25:263–266.

14. Corson SL, Block S, Mintz C, et al. Sterilization of laparoscopes:Issoakingsufficient?*JReprodMed*.1979; 23:49–56.

15. GarnerJS,FaveroMS:Guidelinetohandwashingand hospitalenvironmentalcontrol,1985.*AmIInfectCont*. 1986;14:110–126.

16. Ad Hoc Committee on Infection Control in the Handling ofEndoscopicEquipment(AssociationforPractitionersin Infection Control). Guidelines for preparation of laparoscopic instrumentation. *AORN J*. 1980;32:65–76.

17. RaufmanJP, Straus EW: Endoscopic procedures in the AIDS patient: Risks, precautions, indications, and obligations.*GastroenterolClinNorthAm*.1988;17:495–506

18. SpachDH,SilversteinFE,StammWE:Transmissionof infection by gastrointestinal endoscopy and bronchoscopy. *Ann IntMed*. 1993;118:117–128.

19. American Society for Gastrointestinal Endoscopy. Infection Control During GastrointestinalEndoscopy, Manchester, MA,1988.

20. AyliffeGAJ: Equipment-related infection risks. *JHosp Infect*. 1988; II(suppl.

A)279–284

21. Axon ATR, Bond W, Bottrill PM, et al. Endoscopic disinfection. In *Working Party Reports, World Congressof Gastroenterology, Sydney, Australia*. Blackwell Scientific Publications, 1990. p.45–50.

22. Bond WW, Ott B J, Franke KA, et al. Effective use of liquidchemicalgermicidesonmedicaldevices:Instrument design problems. In: Block SS, ed. *Disinfection, Sterilization,andPreservation*4thed.Philadelphia:Lea&Febiger, 1991. p1097.

23. Ridgway GL: Decontamination offiberoptic endoscopes. *I Hosp Infect*. 1985;6:363–368.

24. CorsonSL,DoleM,KrausR,etal.Studiesinsterilization of the laparoscope II. *J ReprodMed*. 1979;23:57–59.

25. Maki,DG.Theepidemiologyofsurgicalwoundinfection: Guidelines for prevention. *J Surg Prac*. 1977; November- December. p. 10–23

Chapter 8
PRINCIPLES OF ELECTROSURGERY

Bangalore Endoscopic Surgery Training Institute& Research Centre

This is to describe the basic principles of Electrosurgery. Unlike lasers, there has not been any regulatory body on the use of electrosurgery. Traditionally the use of electrosurgery has been learnt from the seniors during surgery, and surprisingly there is hardly anything written about it in any of our standard textbooks of surgery. Inspite of its potential dangers, there is not enough effort to understand the occurrence and prevention of the complications of electrosurgery. This article attempts to give an insight into this topic of utmost importance to any surgeon today.

Definition

One common mistake that we often come across is that the terms "Electrosurgery" and "Cautery" is used for the same purpose while both of them are quite different. By definition, Electrosurgery is the use of radio frequency alternating current to raise the cellular temperature as away to vaporize or coagulate tissue. Cautery is a term derived from "Kauterion" which means "hot iron". It is the destruction or denaturation of tissue by a passive transferof heat or application of a caustic substance.

Biological Effects of Electricity

There are primarily three types of effects produced on tissues by electrical energy.The first type is called Electrolytic effect where anions and cations in the body are attracted to opposite sides. This type of reaction is not conducive to life, and is produced by either *low frequency alternating current or direct current.* The second type of reaction is called Faradic effect which is produced by *high frequency alternating current upto 20 KHz.* This type of current causes stimulation of nerve-endings and muscles, and is commonly used by physiotherapists and neurologists, and sometimes by general surgeons during parotid surgery to detect the branches of the facial nerve, etc. The third is the Thermal effect which is produced by *high frequency alternating current more than 300 KHz (also called radio-frequencyAC).*

There are basically three variable properties of electricity

- Current
- Voltage
- Resistance

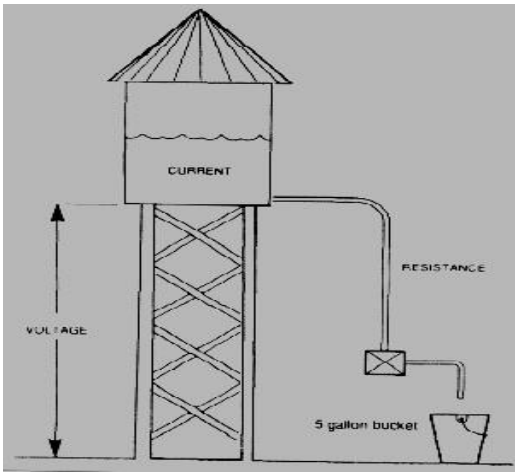
Current (I) is a measure of the electron moment past a given point in the circuit in a fixed period of time. It is measured as *amperes.*

Voltage (V) is the pressure with which the electrons are pushed through the tissue. This is measured as *volts.*

Resistance (R) is the measure of the difficulty that a given tissue presents to the passage of electrons, and is measured as *ohms.*

Power (W) is the capacity to do work per unit time and is measured in *watts*.

All this can be very easily understood using Odell's Water- tower analogy.



Electrosurgical Unit

An Electrosurgical Unit basically does two major functions. It converts a 60 cycles/second (60 Hz), low voltage alternating current into higher voltage radiofrequency (500 KHz to 3.0 MHz) current. Secondly it is capable of producing current with a variety of wave- forms.

Advantages of Electrocutting

They are:

- Reduced bleeding as there is simultaneous haemostatic effect.
- Preclusion of germ implantation, as there is heat produced in the vicinity, and as it is done bysterile technique.
- Avoidance of mechanical damage to the tissue.
- The possibility of using it in endoscopic surgery.

Types of Circuits

There are two types of circuits used to produce diathermy, Monopolar and Bipolar. In the Monopolar diathermy, the electricity travels from the ESU to the patient. The current enters the body of the patient and reaches the dispersive electrode (patient plate), which may be at a distance from the active electrode, and then returns the ESU. As alternating current is used, the direction of current keeps changing several times every second. In the bipolar diathermy, the current passes through one limb of the instrument and returns through the other limb of the instrument. While doing so, it travels through the tissue grasped between the two limbs of the instrument.

In the Monopolar type the effect of the current is seen at close proximity to the active electrode, as the energy is concentrated here, and gets dispersed as it travels towards the dispersive or return electrode. The advantages of using the Monopolar Electrocautery are that it is easy to use and surgery can be performed much faster as it can be used as both cutting and coagulating current. Hence it can be used to dissect tissues also. The disadvantage is that larger volumes of tissue are injured and sometimes distant burns can also occur. It requires a distant return electrode. It may also interfere with pacemakers.

To prevent complications it is important to place the return electrode (patient plate) as close to the operating field as possible, so that the circuit runs only for a short distance in the patient's body. Generally, it is advised to place the dispersive electrode around the arms or the thighs depending in which part of the body the surgery is being performed.

The advantage of using Bipolar Electrocautery is that small volumes of the tissue are injured and there will not be any distant burns. It is a safe mode when used in patients with pacemakers. It is also effective in wet fields. The main disadvantage is that more skill and time is required to use bipolar electrocautery, and that only coagulationcurrent only is available. Hence there is no dissecting capability. But some of the recent machines have incorporated the cutting mode also. *Bipolar offers more safety when being used at close proximity to bowel and other abdominal viscera.*

Tissue Effects of Electrosurgery

There are three types of tissue effects of the radio frequency current, which is used for electrosurgery –

- Vaporization (or Cutting),
- Desiccation (or Coagulation)and
- Fulguration (or superficial coagulation).

Vaporization and fulguration are non-contact procedures, and there is a small distance between the electrode and the tissue. Theelectrical spark travels through a steam bubble from the tip of the active electrode to the tissue to cause the particular effects on the tissue.

Mechanism of action (Cutting / Coagulation)

When an alternating current is used on a cell at a very high frequency (radiofrequency), the anions and cations move to and for within the cell with each cycle of the alternating current. This causes friction and results in increase in the intracellular temperature. *Vaporization* or cutting is caused by *high current and low voltage.* This causes a rapid heating of the cell and formation of steam inside. As a result there is an explosion due to the massive increase in volume of the intracellular contents, and lysisof the cell takes place. *Coagulation* is produced by *a low current and high voltage.* This is a *damped current* and the flow of current is interrupted. Though the increased voltage causes deeper penetration into the tissues, the low current causes slow heating of the cell. This in turn causes dehydration of the cell and the cell shrinks in size.

It is important to recaptulate the Ohm's Law, which says:
$I=V/R$
This, when applied to the formula:$W=VxI$,
$= Vx(V/R)$
$= V^2/R$
where, I = Current, V=Voltage, R = Resistance, and W= Power.
Hence the amount of work done (coagulation performed) is directly proportional to the voltage used and is indirectly proportional to the resistance offered by the nature of tissue on which it is used. A higher voltage leads to a higher spark intensity and a higher spark intensity results in a deeper zone of coagulation during the cutting

process.

The variables that affect the tissue effects of R-F Current are as follows:

- Generator out put
- Power density (Size and shape of electrodes)
- Electrode-tissue proximity
- Tissue impedance
- Electrode speed / time on tissue
- Distension media.

Ideally when tissues have to be cut, a sharp electrode is used in the cutting mode, and the electrode is held at a small distance away from the tissue. Charring effect will be minimal when used in this way. When fulguration (superficial coagulation) is desired, as while obtaining haemostasis over the liver bed, a ball electrode or a spatula is used in the coagulation mode, again holding the electrode at a small distance away from the tissue. If the electrode is pressed firmly over the liver surface, it would cause dessication or deep coagulation. When dissecting tissues and both cutting and coagulation are required, blended modes are used in different ratios of cutting and coagulation. The thickness of the electrode can be selected depending on how much coagulation effect is desired. The speed at which the electrode is moved determines the amount of contact and delivery of energy to the tissues, and thus the amount of coagulation and charring at the margins. In laparoscopy, the Carbon dioxide gas used is not as good a conductor of the electrical energy as air, and thus would alter the performance of electrosurgery.

Electrosurgical burns

During application of electrosurgery three main types of burns can occur:

- Endogenous burns
- Exogenous burns
- Psuedo burns

Endogenous Burns

Endogenous burns are always a result from a too high current density in the patient's tissue. At the active electrode there is a need for high current density in order to cut or coagulate tissue, but accidental pressing of the foot pedal or use of the electrocautery for a longer time or extent can cause burns. There are three mechanisms in which inadvertant burns can occur during use of monopolar electrocautery in laparoscopic surgery.

1. Direct Coupling:

The common cause by which this occurs is when there is insulation failure or when the whole metal part of the instrument is not being visualised while using electrocautery. The instrument may be touching some other tissues outside the laparoscopic visual field, where the instrument may not be insulated adequately. At such a time the current passes to that tissue and causes burns there.

2. Indirect Coupling:

There can be another instrument which can conduct electricity (like telescope,

grasper, etc.,), in close proximity to the instrument through which electricity is passing and the energy can jump and get transferred to this instrument also. Supposing there is some other tissue in close proximity to this instrument then there can be burns of this tissue, which is located far away from the site of surgery. This burn may go unnoticed.

3. Capacitive Coupling:

There is certain amount of energy that leaks on to the reducer if it is made of metal, and usually if the reducer is in contact with a metal canula on its outer aspect, the energy is dissipated on the abdominal wall. In turn the energy goes to the dispersive plate and returns to the E.S.U. But if the reducer is not able to let out the energy (because the outside canula is made of a non-conducting material, like plastic), it gets accumulated in the reducer. When a loop of intestine or some other viscera comes in close proximity to the reducer, it suddenly discharges all the energy to that tissue and can result in burns there. This can be prevented by either using both metal reducer and canula, or both being made of non conducting material. The risk of capacitive coupling burns exists when a combination of metal and plastic ports is used. Certain modifications are incorporated in some new Electro surgical units, like Electrosheild and monitoring devices which are capable of either preventing accumulation of extra energy in the portals or carrying back this energy to the E.S.U.

The usual causes of endogenous burns other than those mentioned are asfollows:

- Patient plate is too small
- Patient plate is not covering the patient's tissue with its entire area. (at least 75% area should be incontact)
- Unintentional contact to other electrically conductive parts, e.g., drip stand or metal parts of the operation table,etc.,

Sometimes there may be concentration of energy at the patient plate or at areas where the patient comes into contact with electric-conductive parts. The current density becomes so high as to burn the patient's tissue.

Exogenous Burns

Exogenous burns are caused from the heat of burning substances such as skin-cleansing lotions, degreasants and disinfectants, also anaesthetics, which have been ignited by sparks between the active electrode and the patient's tissue. Note that alcohol usually burns as invisible flames, since the operating lamp lights brighter than the flame does. This way the patient-burn can only be recognized after it happened.

Pseudo Burns

From time to time minor or major necrosis are found with patients and are regarded as burns but without finding any explanations or reasons of how these burns have been caused.

Endogenous burns can be excluded when the patient did not have contact with electric-conductive parts at the area where the necrosis is found.

Exogenous burns can also be excluded when before or during electrosurgery no

flammable substances were used.

The causes of these burns must be found out by differential diagnosis:

Necrosis caused by pressure to the patient's tissue:
During long operative procedures pressure to the patient's tissue can cause necrosis, for example, during heart surgery when the patient is hypothermic a large tissue necrosis was found post-operatively.

Pressure to the patient's skin caused by rubber-straps being used to fix and attach the patient plate or by contact- clamps being put underneath the patient can again cause necrosis. In many cases this is erroneously diagnosed as patient-burn.

During electrosurgery patient-burns can only occur when the before mentioned facts are existing. It is possible to prevent patient-burns safely when the operating team knows and observes the causes as well as pays attention to these before and during electrosurgery.

Safety Precausions

The following steps should be followed carefully while using electosurgery:

- All connections are carefully checked before the ES unit is puton.
- The patient plate used is always one recommended by the manufacturer.
- The patient plate must always be applied by covering the patient with its entire area as best as possible.
- The conductive surface of the patient plate must always be clean and free from corrosion.
- If gelled patient plates are used, it is most important that the gel is evenly applied over the entire conductive area of the patient plate.
- Prior to use, the patient plate must be checked for damage, especially patient plates made of aluminum foil.
- It is important that the patient plate is applied with the electrically conductive surface to the patient's skin and not with its wrongside.
- The patient plate is applied as close to the operative site as possible.
- Care must be taken that no electrical conductive fluids come between the patient's skin and the patientplate.
- The patient is insulated against all electrically conductive objects by a thick, dry, electrically insulating sheet, placed between the patient, the operating table and the supports. The sheets must not become damp. Areas subject to considerable secretion of sweat, body extremities lying against the trunk or skin-to-skin contacts should be separated by the application of a dry cloth. Drain off urine with catheter.
- During electrosurgery always sparks exist between the active electrode and the patient's tissue.

Therefore do not use flammable or explosive substances or gases during electrosurgery. If flammable or explosive substances have been used, these must be completely removed before activating the electrosurgical unit.

A special precaution to be taken during laparoscopic surgery is that electrosurgery should not be taken during laparoscopic surgery is that electrosurgery should not be used whenever there is bowel perforation. Bowel contains Methane gas, which is released into the peritoneal cavity whenever there is a bowel perforation, and if electrosurgery is used at such a circumstance, it may lead to an explosion.

Assuming good surgical technique and good endoscopic instrumentation with intact insulation, correct connection of cables and proper placement of neutral electrode would go a long way in making this efficient tool safe and a boon to the surgeon especially in this era of laparoscopic surgery.

Argon Beam Coagulation

Like the standard electrocautery units, the argon beam coagulator uses high-frequency oscillating current to generate coagulating heat. The argon beam coagulator differs from standard electrocautery in that it uses a spray of ionized argon gas as the active electrode rather than a metallic blade. This spray allows even, efficient, and broad application of the coagulating current to the tissues. The argon beam coagulator consists of a current generator, a grounding pad, and a handheld active electrode. The device is activated by a foot pedal that initiates the flow of pressurized ion gas through the end of the handheld unit.

Once a solid column of gas connects the handheld active electrode to the patient, the electrical current arcs across the argon gas to the tissues. The type of current used with the argon beam coagulator is almost identical to the type used with standard electrocautery. To use the argon beam coagulator, the handheld unit is held like a pencil with the end directly pointed at the tissue from a distance of 1 to 2 cm. The foot pedal is activated by the same person holding the active electrode (Tate's rule). A jet of argon gas is emitted from the end of the handheld unit, completing the circuit between the argon beam coagulator and the patient. The cautery current is delivered to the surface of the tissue in contact with the argon stream.

To cauterize large surface areas, the unit can be used like a paint brush using slow small strokes across the tissues. The power settings on most units range from 0 to 150 watts. As with the standard electrocautery, conduction is dependent on many factors, including the conductivity of the tissue.

Therefore, it is recommended to start with a relatively low power setting of 50 to 60 watts and increasing asnecessary. Because of its efficiency in coagulating large irregular surfaces, the argon beam coagulator is ideal for obtaining hemostasis along the cut surface of the liver following hepatic resection. The argon beam coagulator can also be helpful in controlling bleeding from minor splenic trauma or other oozing surfaces. It has also been used as a means of tumor debulking by fulgurating metastasis ovarian carcinoma. The argon beam coagulator offers some advantages over conventional electrocautery in that with the argon beam coagulator there is no physical contact between the active electrode and the tissues. This lack of physical contact means that no adhesion of the active electrode to the tissue occurs, which allows for improved eschar integrity. In addition, there is no need to clean the char from the instrument. The flow of argon gas blows the blood and secretions away

from the solid tissue to be coagulated, allowing for effective and efficient coagulation of tissue surfaces that are actively oozing, and less smoke is generated than with conventional electro cautery.

The argon beam coagulator has some disadvantages: its lack of precision and its expenses both with the unit itself as well as the consumable argon gas. In addition, although the argon beam coagulator is excellent at standard coagulation function, it has no coaptive capabilities and is very limited as a dissecting tool. Because the argon beam coagulator is essentially a monopolar electro cautery device, all precautions applicable to monopolar cautery should apply to the argon beam coagulator. Because of the risk of possible injury, it is better to avoid the use of the argon beam coagulator in close proximity to delicate structures such as intestines, major vascular structures, ureters, and bile ducts. With the argon beam coagulator's relative lack of precision, special precautions should be taken to avoid current diversion through metallic instruments or retractors. Inadvertent activation of the pedal can result in significant injury and fire, and so the argon beam coagulator should always be stored in a plastic holster when not in use.Use in laparoscopic surgery has been difficult as the abdomen is a closed cavity and there can be a sudden rise in the intra- abdominal pressure with flow of the argon gas into the abdomen.

Cryotherapy

Cryotherapy is a technique of in situ tissue ablation that uses freezing temperatures to cause cell death. Cryotherapy has been used to treat a variety of benign and malignant lesions. For several decades, in situ destruction of tumor by Cryotherapy has been used for cutaneous lesions. More recently, this mode of therapy has been applied to tumors of the head and neck, cervix, rectum, prostate, breast, and liver. Today sophisticated cryoprobes are available for the delivery of extremely low temperatures by means of pressurized liquid nitrogen. The probes come in varying sizes with differing capabilities. The delivery systems are complex, and their use requires personnel with special expertise in their operation and maintenance.

Although this technology is new and to a degree still unproven, ultrasound-assisted cryotherapy appears to have great promise in the treatment of liver tumors. In situ cryodestruction of tumor is best applied to unresectable or multiple liver metastases from colorectal cancer, where complete tumor ablation may lead to improved long term survival.

Cryotherapy causes tumor destruction and cell death by a combination of several possible mechanisms. These mechanisms include cold shock injury, reduction of cell volume by osmotic dehydration, denaturation of vital cellular enzymes, perforation of cell membranes by intracellular ice crystals, and destruction of tumor microvasculature. To ensure complete cell death, temperatures in the tissue should be lowered to below - 35degree C, maintained in the frozen state for at least 3 minutes, and then slowly thawed. The thawing cycle is particularly important, because too rapid or too slow thawing will allow survival of a portion of the tumor cells. For this reason, at least two freeze-thaw cycles should be applied to each tumor to ensure complete cellular destruction.

Infrared coagulation

The infrared coagulator generates coagulation heat energy by infra red irradiation. The infra red coagulator consists of a transformer unit with a foot pedal switch and a hand held wand. The wand is round metallic cylinder that generates the infrared light that emanates through the crystal lens as at the end of the wand. The heat energy produced by the infrared irradiation causes rapid heating of the tissues in contact with the crystal, and these heating results in desiccation and coagulation.

The infrared coagulator is most useful for coagulating oozing tissue surfaces such as the cut edge of the liver following hepatic resection. The flat crystal is pressed against the tissue in a manner such that little or no light can escape from the end of the wand. The foot pedal is then pressed to activate the wand and generate the infrared irradiation. Approximately 1 to 2 seconds of exposure is usually sufficient to result in tissue coagulation and hemostasis, which are signified by the boiling of fluids at the edge of the crystal and the generation of a small amount of smoke. It is important that the wand not be pulled away from the tissue until the infrared generation has ceased.
After each application, the end of the wand should be wiped with a moist sponge to cool the crystal and to remove char from the tip. The infrared coagulator is an effective device for coagulating oozing surfaces and has the advantage of not requiring electrical current to pass through the patient. Hence, the infrared coagulator does not interfere with ECG monitoring or pace maker function.

Ultrasonic Dissector

The ultrasonic dissector is a surgical tool that uses high- frequency mechanical vibrations to fragment tissue.
Developed in the late 1960s, this technology was originally applied to ophthalmic surgery, but has gained wide use in neurosurgery, hepatobiliary surgery, and oncologic cytoreductive surgery. The ultrasonic dissector system consists of a rather bulky hand piece connected to a function control console that is controlled by a standard foot pedal. The end of the handheld unit consists of a metal contact probe that vibrates at a frequency between 20,000 and 40,000 times per second. Because this vibration frequency is above the audible range, it is referred to as ultrasonic. No audible sound or electro magnetic radiation is emitted and the vibrating tip must be in direct contact with the tissues to bring about its effect. The vibrations are generated by transducers that rely on piezo electric crystals to convert electrical energy into mechanical vibrations.

The ultrasonic dissector fragments tissue by contact with high water content cells. The vibrations generate vapor pockets within the cells that lead to cellular disruption and fragmentation. While fragmenting high water content cells, the dissector does not rapidly disrupt collagen-rich tissue such as blood vessels and ducts. Hence, the device can divide parenchymal tissue while leaving blood vessels intact so that they can be individually ligated prior to division.

The most common general surgical application of the ultrasonic dissector is for the division of the liver parenchyma during hepatic resection. In addition to its use as a dissecting tool, the ultrasonic dissector can be used as a means of tissue ablation. It

has been extensively applied in cytoreductive surgery in the treatment of metastatic ovarian cancer. Ovarian epithelial cancers tend to have a high water content with very little fibrous stroma; hence, these tissues readily fragment with the ultrasonic dissector. When the ultrasonic dissector is used for this purpose, it is important to be aware that tumor infiltration can involve full thickness penetration of hollow or tubular structures such as intestine, bladder, and blood vessels. Therefore, it is important that the surgeon be prepared to deal with possible perforation of these structures. With this in mind, it is always better to order for complete mechanical bowel cleansing with prophylactic intravenous antibiotics for patients undergoing cytoreductive surgery. Additionally, prior to applying the ultrasonic dissector to a tumor that is in close proximity to major vascular structures, it is advisable to first gain proximal and distal control of the vessel.

The ultrasonic dissector is a convenient way of dividing solid organ parenchyma with little blood loss. When used appropriately, this device is relatively safe and mishaps are infrequent. The ultrasonic dissector has some disadvantages. Its high cost, the bulkiness of the unit itself, and it has not been demonstrated to be consistently superior to standard dissecting techniques. For most routine liver resections, we can use a combination of electrocautery and finger fracture technique for noncirrhotic livers and reserve the ultrasonic dissector for patients with mild to moderate cirrhosis.

Ultrasonic knife

The ultrasonically activated scalpel comprises of a high frequency computer controlled generator which converts incoming electrical signals into mechanical vibrations at 55.5 kHz at the blade tip via a hand piece transducer. The amplitude of motion amounts of 50-100 microns depending on the power setting. The moving blade couples with the tissue, resulting in breakage of protein hydrogen bonds and thus protein coagulum forms. This coagulum seals off blood vessels. The whole process operates at 80 degrees C, minimising undesirable tissue damage due to high temperatures.

The ultrasonic knife can perform cutting and haemostasis with minimal tissue damage, and visibility may be improved as there is less smoke. Energy flows in a longitudinal direction thus limiting its lateral spread and thermal injury. Unlike electrosurgery, no electrical energy is transferred to patients, and extra safety can be ensured. In addition, the linear relationship between variables such as duration of application does not plateau, making the system more controllable as injury occurs gradually and reproducibly over time. The range of blades available serves both open and laparoscopic surgery. They are available in both 5 and 10mm diameter for laparoscopy. In addition to the grasping instrument, various other typesare available such as the hook or the ball coagulators.

Though used for many surgeries, the most well studied application is in laparoscopic fundoplication, in which short gastric vessels are cut haemostatically. Other applications include laparoscopic colectomy, adrenalectomy and gastric surgery besides others.

Lasers

The term "Laser" is an acronym which stands for Light Amplification by the Stimulated Emission of Radiation. The word radiation does not mean ionising type of radiation, but refers to a "radiant" body, i.e, one that "shines" with light energy. Light is comprised of photons of energy. The normal tendency of light is to scatter in all directions. Laser light contains of photons released in an organised fashion called stimulated emission.

Three unique qualities of laser light that differentiate it from regular light are its coherence, monochromaticity and collimation. Coherence means that the wave patterns of the light energy being emitted in a laser are orderly and similar. The laser waves are always precisely in phase with one another, temporally and spatially. This property of a laser would be of use for diagnostic and scanning applications.
The term monochromaticity means that lasers produce pure colours of light. They are always of the same wavelength and energy level. This is a property that is useful for us because of the fact that different tissues absorb various colours differently. Various chemical elements emit characteristic colours of light, and the laser is named after the material used. The term collimation means that laser light travels with all its waves bound tightly together, as a parallel beam in space. This particular property of lasers is what allows the beam to be finely focussed to intensify its effects and is the major characteristic allowing its surgical use.

The surgical effects of the laser are due to localised heating when the light is absorbed by the tissues. As tissue begins to heat, it blanches white as it coagulates, then shrivels as it dessicates, and finally turns to steam and vapour as it is vaporized above 100 degrees C. The heat-generating effect of the lasers is used for surgical applications. Lasers produce heat that is localized and produce desired surgical effects with associated haemostasis.

There are five types of lasers primarily being used for surgical applications. They are

- Carbon dioxide (CO2)
- Nd:YAG (Neodymium: YAG)
- Argon
- Ho: YAG (Holmium: YAG)
- KTP (produced by altering the infrared output of the Nd:YAG laser with a KTP crystal)

These lasers are used in two basic ways. One is a noncontact method whereby the laser light is absorbed by tissue and heat is generated. The other is the contact method by which special fibre tips are heated by the laser and this heat is in turn transferred to the tissue by contact with the fibre.

The factors that determine the amount of laser that is delivered to the tissue are:

- Power (watts) with which the delivery system isoperated.
- Duration for which it was operated.
- Power density (the size of focused spot used to intensify the light).
- Colour of the laser light.
- Colour and vascularity of the tissue.

The surgeon can control the power setting, the duration of application and the spot size of the beam, and thus modify the effect of the laser on tissue. A laser beam can be used either as a continuous mode or a pulsed mode. A pulsed mode is a brief beam which is delivered in fractions of a second. This type of delivery gives a good control to the surgeon to deliver precise doses of high power. This type of delivery provides a longer reaction time and produces less spread of heat damage to the distant organs. In the absence of such a mode of delivery in the laser machine, a pulsed mode can still be used by operating the foot pedal appropriately to produce controlled bursts.

Any type of laser can be used to cut or vaporize by altering the way it is used. For laparoscopic surgery we could use a CO2 laser laparoscope, or regular fibres to deliver argon, KTP, Ho:YAG and free beam Nd:YAG lasers. In a CO2 laser laparoscope, the laser beam first focuses to a point and then diverges. Hence it maintains a long depth of field and it can burn or vaporize tissues distal to the target organ or tissue. Therefore while using this laser, it is essential to have a backstop to prevent distal injury. When a fibre is used, the beam starts of diverge immediately distal to the beam. Hence this beam does not stay focussed beyond an inch or two from the tip of the fibre.

The advantage of the fibres is that different effects can be accomplished quickly with only a slight motion of the fingers holding the fibre hand-piece. A small pinch back with the fingers allows small blood vessels to be photocoagulated, then a small pinch forward to bring the fibre end just over tissue results in a cut, both at the same power settings on the machine. The short range of effect also reduces the need for intraabdominal backstops. The argon and KTP are the primary fibreoptic lasers for laparoscopy besides contact type modalities, which are mainly Nd:YAG lasers.

The CO2 laser provides a great deal of versatility in the "reach" it provides from the end of the laparoscope, the number of angles where it can work, and the speed at which it can vaporize or cut if desired. In this sense it is probably more versatile than a fibre system, but it has a significant longer learning curve and does not provide the hemostasis than fibre systems provide. It also requires a specialized laparoscope set and coupler to mate the laser with the scope.

Fibres terminating in some device such as a metal tip, sapphire probe, or even an altered shape of the fibre tip generate a significant amount of heat at this tip and are referred to as hot tip devices. They act as very intense, precise knives. Energy concepts such as power density do not really apply to contact devices, since they rely on simple heat conduction. The Nd:YAG laser is the primary one used for hot tip devices in laparoscopic surgeries. Some of the hot tip devices, such as rounded or chisel sapphire tips, do actually focus some of the laser light, so that combination effects may occur. A combination rounded tip fibre can be backed off from the tissue to vaporize or coagulate as free beam or touched to tissue to cut as a hot tip.

The safety of the patient and the operating team is very important. Trained, experienced assistants are invaluable during laser procedures. Operation theatres must be clearly labeled on the outside door indicating that a laser procedure is in progress. The window in the operating room must be covered. The type of laser

must be specified on the "danger" sign. The optical density for protective eye wear must be appropriate for the wavelength of the laser being used. All personnel, including the anaesthesiologist and assistants, must wear safety goggles or appropriate protective eye wear. It is absolutely essential that flammable substances or explosive solutions be avoided in the operating room during laser usage. Special care must be taken when using paper drapes. When using CO2 lasers the area surrounding the operative field should be draped with moist laps. The patient's eyes must also be appropriately protected with moist gauze ordressings.
The production of smoke after tissue destruction with the lasers has led not only to respiratory complications, but has been implicated as a possible source of mutagenicity.
Approximately 75% of the solid particulate matter in laser plume is less than 1 micron. When inhaled, this small particulate matter is capable of travelling directly to the distal tracheopulmonary tree and being deposited in individual alveoli. To eliminate 99% of the generated plume, a suction device that can mobilize 28 litres of air /sec when held 1cm from the origin of the laser plume is needed. Although CO_2 laser laparoscopy is associated with more plume formation than the Argon, Nd:YAG, or KTP lasers, adequate smoke evacuation systems are still mandatory when using the latter three wave lengths.

There are no prospective, blinded studies comparing laparoscopic use of lasers with conventional electrosurgery, which have demonstrated a reduction in adhesion formation or an improvement in pregnancy rates. Its use to date is based on the clinical impression primarily of the surgeon.
Many surgeons advocate the use of lasers because of their controlled depth of penetration, reduced thermal damage to adjacent tissue, and the reproducibility of the effects of lasers on tissue.

Reference:

1. Christopher MJ, Ketsia BP, Ian BN, et al.Electro surgery. *Cur Surg*.2006;63:458
2. Wu MP, Ou CS, Chen SL, Yen EYT,Rowbotham R. Complications and recommended practices for electrosurgery in laparoscopy. *Am J Surg*. 2000;179:67–73
3. Nezhat CH, Nezhat F, Brill I, Nezhat C. Normal variationsofabdominalandpelvicanatomyevaluatedat laparoscopy. *Obstet Gynecol*.1999;94:238–242
4. Jones CM, Pierre KB, Nicoud B, Stain SC,Melvin WV. Electrosurgery. *CurrSurg*.2006;63:458–463
5. Van Way CW, Hinrichs CS. Technology focus: electrosurgery201:basicelectricalprinciples.*CurrSurg*. 2000;57:261–264
6. Valleylab*Principles of electrosurgery*.1999;1–23
7. Advincula AP, Wang K. The evolutionary state of electrosurgery:wherearewenow?*CurrOpinObstet Gynecol*.2008;20(4):353–358
8. MassarwehN,CosgriffN,SlakeyD.Electrosurgery: history, principles, and current and future uses. *AmColl Surg*. 2006;202:520–530
9. Wang K, Advincula AP. Current thoughts in

electrosurgery.*IntJGynaecolObstet*.2007;97:245–250
10. NeufieldGR.Principlesandhazardsofelectrosurgery including laparoscopy. *Surg Gynecol Obstet.* 1978;147:705–710
11. Miller CE. Basic equipment and room setup. In: Shirk GJ,Editor,*TheVideoEncyclopediaofEndoscopicSurgery fortheGynecologist*.StLouis:MedicalVideoProductions; 1994;11–19
12. PhippsJH.Understandingelectrosurgery:safetyand efficiency. In: Lower A, Sutton Cand., Grudzinskas G, eds. *Introduction to Gynecological Endoscopy*. Oxford, UK: Iris Medical Media;1996;39–56
13. Tucker RD, Schimitt OH, Sievrt CE, et al. Demodulated low frequency currentsfrom electrosurgical procedures. *Surg GynecolObstet*. 1984;159:39–43
14. Martin DC, Soderstrom RM, Hulka JF,et al. Electrosurgery safety. *Am Assoc GynecolLaparoscTech Bull*. 1995;1–7
15. Ryder RM, Hulka JF. Bladder and bowel injury after electrodesiccation with Kleppinger bipolar forceps: a clinicopathologic study. *J ReprodMed*.1993;38:595–598
16. Tucker RD, VolyesCR. Laparoscopic electrosurgical complicationsandtheirprevention.*AORN*.1995;62:49–78
17. Nduka CC, Super PA, Monson JR, Darzi AW. Cause andpreventionofelectrosurgicalinjuriesinlaparoscopy.*J Am Coll Surg*.1994;179:161–170
18. Hulka JF, Levy BS, Parker WH,Philips JM. Laparoscopic-assisted vaginal hysterectomy: American Association of Gynecologic Laparoscopists 1995 membership survey. *J Am Assoc GynecolLaparosc*. 1997;4:167–171
19. VancaillieTG. Active electrode monitoring. Howto prevent unintentional thermal injury associated with monopolar electrosurgery at laparoscopy. *Surg Endosc*. 1998;12:1009–1012
20. Montero PN, Robinson TN, Weaver JS, StiegmannGV. Insulation failure in laparoscopic instruments.*Surg Endosc*.2010;24:462–465
21. Odell RC. Electrosurgery: biophysics, safety and efficacy. In: Mann WJ T, Stovall G, eds. *Mann/Stovall GynecologicSurgery*.NewYork:ChurchillLivingstone; 1996;55–67
22. VilosG, Latendresse K, Gan BS.Electrophysical properties of electrosurgery and capacitive induced current. *Am J Surg*.2001;182:222–225
23. Soderstrom RM. Bowel injury litigation after laparoscopy.*JAmAssocGynecolLaparosc*.1993;1:74–77
24. Levy BS, Soderstrom RM, Dail DH. Bowel injuries during laparoscopy: gross anatomy and histology. *JReprodMed*.1985;30:168–172
25. Reich H. Laparoscopic bowelinjury. *Surg LaparoscEndosc*.1992;2:74–78
26. Saltzstein EC, Schwartz SF, Levinson CJ.Perforation of the small intestine secondary to laparoscopic tubal cauterization. *Ann Surg*.1973;178:34–37
27. Mayooran Z, Pearce S, TsaltasJ, et al. Ignoranceof electrosurgery among obstetriciansand gynaecologists. *BJOG*. 2004;111:1413–1418
28. HaroldKL,PollingerH,MatthewsBD,KercherKW, Sing RF, HenifordBT.

Comparison of ultrasonic energy, bipolar thermal energy, and vascular clips for the hemostasis of small-, medium-, andlarge-sized
arteries. *Surg Endosc*. 2003;17:1228–1230

29. Carbonell AM, Joels CS, Kercher KW, MatthewsBD, Sing RF, HenifordBT. A comparison of laparoscopic bipolarvesselsealingdevicesinthehemostasisofsmall-, medium-, and large-sized arteries. *J Laparoendosc Adv Surg Tech A*.2003;13:377–380

30. Pietrow PK, Weizer AZ, L'Esperance JO, Auge BK, Silverstein A, Cummings T, et al. Plasma kineticbipolar vessel sealing: burst pressures and thermal spread in an animal model. *J Endourol*.2005;19:107–110

31. Richter S, Kollmar O, Schilling MK, PistoriusGA, Menger MD. Efficacy and quality of vessel sealing: comparison of a reusable with a disposable device and effects of clamp surface geometry and structure. *Surg Endosc*.2006;20:890–894

32. LambertonGR,HsiRS,JinDH,LindlerTU,Jellison FC, Baldwin DD. Prospective comparison of four laparoscopic vessel ligation devices. *J Endourol*. 2008;22(10):2307–2312

33. Hefni MA, Bhaumik J, El-ToukhyT, et al. Safety and efficacy of using the LigaSure vessel sealing system for
securingthepediclesinvaginalhysterectomy:randomised controlled trial. *BJOG*.2005;112(3):329–333

34. LeeSJ,ParkKH.Ultrasonicenergyinendoscopic surgery. *Yonsei Medical Journal*.1999;40:545–549

35. Shimi SM. Dissection techniques in laparoscopic surgery: a review. *J R Coll Surg Edinb*.1995;40:249–259

36. Goldstein SL, Harold KL, Lentzner A,et
al. Comparison of thermal spread after ureteral ligation with the laparosonic ultrasonic shears and the ligasure system. *J Laparoendosc Adv Surg Tech A*. 2002;12:61–63

37. HenifordBT, Matthews BD, Sing RF, et al. Initial results with an electrothermal bipolar vesselsealer. *Surg Endosc*.2001;15:799–801

38. Sutton C. Power sources in endoscopic surgery.*CurrOpinObstet Gynecol*.1995;7:248–56

39. Hindle AK, Brody F, Hopkins V, Rosales G,Gonzalez F, Schwartz A. Thermal injury secondary to laparoscopic optic cables. *Surg Endosc*.2008;23:1720–1723

40. Ulmer B. *Electrosurgery Continuing Education Module*. ValleylabInstitute of Clinical Education,2000

41. AORNRecommendedPracticesforElectrosurgery, 2003

42. Randle Voyles C, Tucker RD. Safe use of
electrosurgicaldevicesduringminimallyinvasivesurgery. In: Wetter PA, ed. *Prevention & Management of Laparoendoscopic Surgical Complications*, 2nd Edition Miami, Florida, USA: Society of Laparoendoscopic Surgeons, Inc.,2005

Chapter: 9
COMPLICATIONS OF LAPAROSCOPIC SURGERY

Laparoscopic surgery has become the gold standard in the management of many diseases especially gall stones.
Experience and maturation of technique has allowed the procedures to be performed in difficult cases. We have also come to understand that the procedures are accompanied by a number of complications. The severity and frequency of these complications can be reduced by careful attention to technique. The proper preparation of the patient and judicious use of conversions to laparotomy will reduce these complications.

Patients should be well informed of the advantages and potential disadvantages of the laparoscopic procedure. They must understand that the procedure is not a magic trick but is a major surgery performed with video guidance. Fasting for at least 8 hr. before surgery is the rule. Insertion of a urinary catheter empties and protects the bladder and is important if the Veress needle technique is used to establish pneumoperitoneum.The catheter is rarely needed, however, if the open method of peritoneal access is performed.

Achieving Pneumoperitoneum
This step in the performance of laparoscopic surgery often seems trivial, but is extremely crucial to the success and safety of the entire procedure. Carelessness or poor judgement at this point in the method can result in severe injury to the patient. Use of the Veress needle to create pneumoperitoneum is a safe and time tested technique. The operator must ensure that the "pops" of the various layers of the abdominal wall are felt, that no fluid is aspirated as the needle enters the Abdomen and that a drop of water placed into the needle's barrel falls into the needle.

After attaching the gas lines to the needle, pressures should be very low, indicating no resistance to flow (I recommend the **"Golden Rule of 5"** - the initial intra-abdominal pressure being less than 5 mm of Hg and the rate of gas insufflation being more than 0.5 Lit/min). If pressures are high, one should consider a second insertion at another site to localize and repair the first needle puncture injury (if any), or one should proceed to laparotomy. Severe injuries to viscera and great vessels have occurred because of thrusting the needle deep into the abdomen. Any evidence of puncture of a major vessel should prompt laparotomy to allow inspection and repair of the vessel if necessary.

An easy solution might seem to be direct cut down by the Hassan method into the abdomen at the umbilicus. It is not, however, without potential pitfalls. Bowel may be injured when the abdomen is entered, and injury may go unrecognized causing later peritonitis and sepsis. It is crucial that the bowel beneath the site be inspected on introduction of the telescope, and before removal of the telescope, the site be inspected from another port.

TYPES OF COMPLICATIONS:

Anaesthesia-related Problems

One-third of deaths associated with minor laparoscopic procedures such as sterilization are secondary to complications of anesthesia. Among the potential complications of all general anesthetics are hypoventilation, esophageal intubations, gastroesophageal reflux, bronchospasm, hypotension, narcotic overdose, cardiac arrhythmias, and cardiac arrest. Laparoscopy, when performed with CO2 or nitrous oxide (N20) insufflation induces change in several parameters of cardiopulmonary function, such as reduced pO2, O2 saturation, tidal volume and minute ventilation, and an increased respiratory rate. The use of intraperitoneal CO2 as a distension medium is associated with an increase in pCO2 and a decrease in pH. Elevation of the diaphragm may be associated with basilar atelectasis, a resultant right-to-left shunt and a ventilation perfusion mis match.

CARBON DIOXIDE EMBOLUS

CO2 is the most widely used peritoneal distension medium. Most CO2 micro-emboli are absorbed, usually by the splanchnic vascular system, quickly and without incident. However, severe cardio respiratory compromise may result if large amount of CO2 gains access to the central venous circulation, such as with inadvertent intravascular placement of an insufflation needle.

Diagnosis: The presenting signs of CO2 embolus include sudden, otherwise unexplained hypotension, cardiac arrhythmia, cyanosis, and development of a classic “mill wheel” heart murmur. Other clinical sequelae include increased tidal CO2, findings consistent with pulmonary edema, and pulmonary hypertension, resulting in right- sided heart failure.

Risk Reduction: A number of steps may be taken to reduce the risk of CO2 embolus. It is important to ensure that blood is not emanating from the needle before the distending gas is introduced. Operating with the intraperitoneal pressure always less than 20mm Hg also reduces the risk of CO2 embolus. In most instances, except for the initial placement of trocars in an insufflated peritoneum, the surgeon should be able to function comfortably with the intraperitoneal pressure at 8-12 mm Hg.

The risk of CO2 embolus is further inhibited by the meticulous maintenance of hemostasis, because open venous channels are a portal of entry for gas into the systemic circulation. Another option that should virtually eliminate the incidence of CO2 or other gas emboli is the use of “gasless” or “apneumic” laparoscopy, in which extra-or intraperitoneal lifting mechanisms are used to create a working space for the surgeon. Such devices have yet to gain wide acceptance.

Management: When CO2 embolus is suspected or diagnosed, the operating room team must act quickly. The surgeonmustimmediatelydecompresstheperitonealcavity and place the patient’s head below the level of the right atrium, in the Durant, or left lateral decubitus position. Immediately establishment of a large-bore central venous line may allow aspiration of gas from the heart. Because the findings are nonspecific, other causes of cardiovascular collapse should beconsidered.

CARDIOVASCULAR COMPLICATIONS

Hypercarbia and the resulting acidemia are the principle reasons for the relatively frequent development of cardiac arrhythmias during laparoscopic surgery.The

anesthesiologist must be careful to select agents that limit the risk of cardiac arrhythmia. Operating with intraperitoneal pressures less than 12 mm Hg may reduce the incidence of hypercarbia-associated arrhythmias. Although during laparoscopy the most common cause of low blood pressure is hemorrhage, hypotension can also occur secondary to excessive intraperitoneal pressure and result in decreased venous return, which causes decreased cardiac output. This undesirable result may be potentiated if the patient is volume depleted.

GASTRIC REFLUX

Gastric regurgitation and aspiration are complications potentiated by laparoscopic surgery, especially when the patient is in Trendelenberg position. The surgeon can contribute to aspiration prophylaxis by operating at the lowest necessary intraperitoneal pressure. Patient should be taken out of the Trendelenberg position before being extubated.

HAEMORRHAGE

Great Vessel Injury: The most dangerous hemorrhagic complications of entry are from injury to the great vessels, including the aorta and vena cava and the common iliac vessels and their branches, the internal and eternal iliac arteries and veins. Trauma most often occurs secondary to insertion of an insufflation needle, but catastrophic results may result from the tip of sharp trocar inserted with closed technique.

Diagnosis: Most often the problem manifests in profound hypotension with or without the appearance of a significant volume of blood within the peritoneal cavity. Frequently, bleeding is contained in the retroperitoneal space, which usually delays diagnosis. Consequently, the patient may develop hypovolemic shock in the recovery room, secondary to the unrecognized laceration of a great vessel. To avoid this problem it is important to evaluate the course of each great vessel before completing the procedure.

Risk Reduction: The incidence of large vessel trauma can be minimized in several ways. Use of “open laparoscopy” for the initial port has been suggested as one way to entirely avoid the issue of great vessel injury secondary to insufflation needles and trocars. Although the incidence of injury to great vessels may be reduced, injuries to the aorta and vena cava have been incurred, probably because of reduced exposure during open laparoscopy. Insufflation needles and the trocar should be kept sharp or should be disposable. The spring-loaded obturator of the insufflation needle should be checked to ensure that the sliding mechanism is functioning normally. Many disposable trocar-cannula systems are constructed with safety mechanism that covers or retracts the trocar after passage through the fascia and peritoneum. However, no current data demonstrate that these devices reduce the incidence of major vessel injury. The application of appropriate technique is based upon.

Management: Blood withdrawn from the insufflation needle should be left in place while immediate preparations are made to obtain blood products and perform laparotomy. If the diagnosis of hemoperitoneum is made at initial visualization of the peritoneal cavity, a grasping instrument may be used, if possible, to temporarily

occlude the vessel. Although significant injury is unlikely to be repaired by laparoscopically directed technique, if temporary hemostasis can be obtained and the laceration visualized, some localized lesions can be repaired with suture under laparoscopic guidance. However, only experienced, technically adept surgeons should make such an attempt, and fine judgment should be used.

ABDOMINAL WALL VESSEL INJURY

By far the most commonly injured abdominal wall vessels are the superficial inferior epigastric vessels as they branch from the femoral artery and course cephalad in each lower quadrant. These vessels are invariably damaged by initially passage of an ancillary trocar or by a wider device introduced later in the procedure. The problem may be recognized immediately by observation of blood dripping along the cannula or out through the incision. However, it is not uncommon for the cannula to obstruct bleeding until withdrawal at the end of theprocedure.

Diagnosis: Injury can be diagnosed by visualization of blood dripping down the cannula, by the post operative appearance of shock, abdominal wall discoloration, or a hematoma located near to the incision. In some instances blood may track to a more distant site and present as pararectal or vulvar mass. Delayed diagnosis may be prevented at the end of the operation by laparoscopic evaluation of each peritoneal incision after removal of the cannula.

Risk Reduction: Transillumination of the abdominal wall from within the peritoneal cavity usually provides identification of the superficial inferior epigastric vessels. However, the deep inferior epigastric vessels cannot be identified this way because of their location deep to the rectus sheath. At the pubic crest, the deep inferior epigastric vessels begin their course cephalad between the medially located medial umbilical ligament and the more laterally positioned exit point of the round ligament. The trocar should be inserted medial or lateral to the vessels, if they are visualized. If the vessels cannot be seen, and it is necessary to position the trocar laterally, the trocar should be inserted 3-4 cm lateral to the median umbilical ligament. Too lateral an insertion endangers the deep circumflex epigastric artery.

A common mistake is to fashion the skin incision appropriately, but then direct the trocar medially through the abdominal wall, which injures the vessels. Another factor that my contribute to the risk of injury is use of large-diameter trocars and cannula. Consequently, it behooves the surgeon to use the smallest cannula necessary for performance of the procedure.

Management: Superficial inferior epigastric artery lacerations usually respond to expectant management. Rotation of the cannula to a position in which compression is possible is also helpful. Rarely is a suture necessary. For the ligation of lacerated deep inferior epigastric vessels, it is found that the use of a modified, straight ligature carrier is most useful. After removal of the trocar and cannula, the ligature carrier is used to advance a suture laterally and inferiorly under laparoscopic guidance, the suture is held in place by grasping forceps.

The ligature carrier is removed and subsequently passed through the incision again, this time without a suture, medial and inferior to the lacerated vessels. The suture is

threaded into the carrier from within the peritoneal cavity then externalized and tied. For small incisions (narrower than the diameter of the surgeon's finger), the knot may be tightened with a laparoscopic knot manipulator. The most obvious method is placement of large, through-and-through mattress sutures, usually removed after about 48 hr.

INTRAPERITONEAL VESSEL INJURY

As with any intraperitoneal surgical procedure, hemorrhage may occur from injury to vessels encountered in the course of the surgical dissection.

Risk Reduction: During dissection, vessels should be identified and occluded before division, a task made simpler by the magnification afforded by the laparoscope. Electrosurgical coagulation, if used, should be applied in the appropriate waveform and power density long enough to allow sufficient tissue desiccation. Clips should be of a size appropriate for the vessel, and they must be applied in a secure fashion with an adequate pedicle of tissue.

Management: Transected vessels should be secured immediately. Arteries larger than 3mm in diameter are less reliably occluded with desiccation than are arteries less than 3mm. If bipolar electrosurgical desiccation is used to maintain or achieve hemostasis, a serial ammeter is useful to demonstrate the end point of energy application. Blind clamping followed by electrosurgical desiccation must be avoided,even with bipolar instruments, especially when the location is less than 1 cm from ureter or bowel. When a vessel is in this location, securing it with clip is usually preferable.

GASTROINTESTINAL COMPLICATIONS

Insufflation Needle Injuries

Needle entry into the stomach occurs in the presence of gastric distension or when adhesions bind the stomachto the abdominal wall. Mechanical entry into large or small bowel may occur in any instance, but is up to 10times more common when laparoscopy is performed on patients with previous intraperitoneal inflammation or abdominal surgery.

Diagnosis: Recognizing gastric entry by the insufflation needle may follow identification of signs of extra peritoneal entry, such as increased filling pressure, asymmetric distension of the peritoneal cavity, or the aspiration of gastric particulate matter through the lumenof the needle. However, the hollow capacious nature of the stomach may allow the initial insufflation pressure to remain normal. Recognition of bowel entry usually follows observation of the signs described for gastric injury, with, in the case of colonic entry, the addition of feculent odor.

Management: the management of any trauma to the gastrointestinal tract partially depends on the nature of the injury and on the organ(s) involved. In general,

insufflation needle punctures that have not caused a defect significantly larger than their diameter may be handled expectantly. Large defects should be repaired or resected by laparoscopic or laparotomy-based technique according to the skill of the surgeon and the extent of the lesion.

TROCAR INJURIES

Damage caused by sharp trocar penetration is usually more serious than injury from a needle. Most often, injury is created by the primary trocar because of its blind insertion.

Diagnosis: When a primary trocar inserted with closed technique penetrates bowel, the diagnosis is usually made when the surgeon visualizes a mucosal lining after the laparoscope is inserted. If large bowel has been entered, a feculent odor maybe noted. However, in some instances, the injury may not be recognized immediately because the cannula may not remain in place or may pass through the lumen and out on the other side of the viscus. Such injuries usually occur when a loop of bowel is adherent to the anterior abdominal wall near the entry point. Consequently, at the end of the procedure one should directly view the removal of the primary cannula, either through the device itself or via an ancillary port. Unfortunately, the lesion may go unrecognized until it presents post operatively with peritonitis, abscess enterocutaneous fistula, or death.

Risk Reduction: Trocar injury to the stomach is generally eliminated with liberal use of oral or nasogastric decompression. Bowel injuries usually occur when the intestine is adherent to the abdominal wall under the site of trocar insertion. Consequently, preoperative mechanical bowel preparation should be used for high-risk patients to facilitate repair of colonic injury without the need to perform a laparotomy/colostomy.

Despite the widespread use of disposable cannula insertion systems with retractable trocars or safety sheaths, injury to bowel or other structures may occur. Many surgeons routinely use open laparoscopy, but bowel entry may still occur. An alternative approach, especially when one enters an abdomen with previous laparotomy scars, is left upper quadrant insertion, preferably with an insufflation needle especially designed to allow passage of a narrow laparoscope. This approach allows direct visualization of the abdominal wall under the umbilicus or other planned site of insertion and may facilitate dissection of underlyingadhesions.

Management: Trocar injuries to the gastrointestinal tract almost always require repair. If one can ascertain that the injury is isolated and if the surgeon is experienced, the lesion may be repaired with appropriate suture by laparoscopic guidance. Extensive lesions may require resection and reanastomosis, which can be performed with laparoscopic direction but usually requires laparotomy. If the injury is to sigmoid colon, primary repair may be attempted if the bowel has been mechanically prepared preoperatively. If uncertainty exists regarding the extent of injury, laparotomy is always indicated.

DISSECTION AND THERMAL INJURY

Diagnosis: Any amount of dissected bowel should be carefully examined during the dissection because comprehensive “running” of the bowel near the end of the procedureisfarmoredifficultunderlaparoscopicguidance. Thermal injury to bowel may be more difficult to diagnose intraoperatively, particularly if the injury was created with electrical or laser energy,a feature that makes careful adherence to safety protocols imperative. Even if thermal injury is recognized, estimating the extent of the damage visually is difficult because the zone of desiccation may exceed the area of visual damage. An understanding of the differing impacts of various types of electrical current is essential to estimate the extent of injury. In some instances, diagnosis is delayed until the patient develops peritonitis and fever, which usually occurs a few days after the procedure but occasionally does not happen for several weeks.

Risk Reduction: When one is dissecting, adequate exposure of the operative field must be accomplished, frequently with the retraction and counter traction provided by a competent assistant. Dissection close to bowel should be performed mechanically with sharp scissors, not with electrical or laser energy sources. Occlusion of blood vessels near to bowel is accomplished with clips, or bipolar current, provided that an adequate margin of tissue exists. Regardless, if the difficulty of the dissection makes the surgeon uncomfortable, alternative methods of hemostasis should be used. If other methods are not feasible, one should seek the aid of a more experienced colleague, abandon the procedure or convert to an open procedure.

Management: Thermal injury may be handled expectantly, if, in the estimation of the surgeon, the lesion is superficial and confirmed. Estimating the degree of tissue injury is possible if one knows the nature of the current and other parameters, such as the wattage, current density, and duration of contact withtissue.

UROLOGIC INJURY

Laparoscopy-associated damage to the bladder or ureter may occur secondary to mechanical or thermal trauma.

Diagnosis: As with all visceral trauma, intraoperative identification of the injury is the most important aspect of management. The diagnosis is relatively easy if thesurgeon recognizes entry into a hollow viscus or urine in the opeative field. Hematuria suggests urinary tract injury and pneumaturia (CO_2 in the indwelling drainage system) is diagnostic of vesical entry.

The existence of a bladder laceration may be confirmed with the injection a dilute methylene blue solution via an indwelling catheter. Thermal injury to the bladder may not be initially apparent; it frequently presents later in the patient’s postoperative course when the traumatized area sloughs off and allows egress of urine into the peritoneal cavity.

Ureteric lacerations may be proven intraoperatively with the systemic injection of indigo carmine dye. Intraoperative recognition of mechanical obstruction secondary to staples or suture can be made by direct visualization of the occlusion or realized

when cystoscopic imaging fails to demonstrate injected indigo carmine dye entering the bladder from the affected side.

Unfortunately, diagnosis is frequently delayed until after the procedure. Thermal injury presents 24 hours to 14 days after surgery with fever, abdominal or flank pain, clinical findings of peritonitis, or a combination of these signs. Leukocytosis may be present. An intravenous pyelogram can demonstrate extravasation of urine or a urinoma. Not surprisingly, cases of laparoscopy-associated ureteric obstruction seem to present at a time similar to that for cases after laparotomy based procedures- a few days to1 wk after the operation, usually with flank pain and fever. The diagnosis may be suggested by abdominal ultrasound, but intravenous pyelogram can be more precise at identifying the site and degree of the obstruction.

Uretero-or vesicovaginal fistula presents in a delayed fashion with urinary incontinence or vaginal discharge. Bladder fistula can be confirmed by direct visualization or the leakage of instilled methylene blue onto a tampon. A ureterovaginal fistula does not pass methylene blue from the bladder; it can be identified by intravenous injection of indigocarmine.

Risk Reduction: Trocar related bladder injuries are generally preventable with routine preoperative bladder drainage. Additional caution must be exercised in the patient previously exposed to abdominal or pelvic surgery because there may be scarring and retraction that pulls the bladder above the level of the symphysis pubis. The urachus, although rarely patent, should be avoided if possible. For prolonged or difficult cases, placement of an indwelling catheter may reduce the incidence of injury resulting from dissection. However, sharp mechanical dissection is preferred, particularly when relatively dense adhesions are present.

A requisite to risk reduction is knowledge of the ureter’s anatomy as it courses through the pelvis. It is essential to understand the proximity of the ureter to the uterine artery, the cervix, and the uterosacral ligaments and to realize that any of these relationships may be distorted by previous surgical dissection or by disease such as endometriosis orleiomyomas.

If the surgeon cannot, with assurance, steer a wide path from the ureter’s course, the ureter must be directly visualized, especially when laser, electrosurgical, or stapling techniques are used. Frequently, the ureter can be seen through the peritoneum of the pelvic sidewall between the pelvic brim and the attachment of the broad ligament. However, even in this location, the location of the ureter can be obscured because of anatomic variation or the presence of pathology, situations that mandate dissection of the retroperitoneal space.

Treatment: Small caliber (1-2mm) injuries to the bladder heal spontaneously with prolonged catheterization. However, the duration of catheterization can be reduced or eliminated if repair is undertaken intraoperatively. A fairly significant injury to the bladder can usually be repaired under laparoscopic direction, provided the surgeon has adequate surgical skill and the location is amenable to laparoscopic technique. Further evaluation of the location and extent of the laceration may be provided by direct laparoscopic technique. Further evaluation of the location and extent of the laceration may be provided by direct laparoscopic examination of the

bladder lumen with use of a small caliber endoscopes (1.5-2.0 mm in diameter). If the laceration is near to or involves the trigone, open repair may be preferable.

For relatively small lesions, a single layer, simple or purse string closure may be fashioned using syntheticabsorbable sutures of 2-0 or 3-0 caliber and tying the knot either intra or exracoporeally. For linear lacerations, the defect is preferably closed in twolayers.

If significant thermal injury exists, excising the damaged area before repair may be advisable. Postoperative catheterization with a large- caliber urethral or suprapubic catheter should be maintained for 5-7 days for simple fundal lacerations and for 2 week for injuries closer to the trigone or the vaginalvault.

Intraoperative diagnosis of ureteral injury provides the opportunity for intraoperative management. Very limited damage may respond adequately to the passage of a ureteric stent for 10-20 days. In most instances, however, repair is indicated according to the surgical principles for open procedures.

When the diagnosis of obstructive ureteral injury is delayed until after surgery, the first imperative is to establish drainage. Some incomplete or small obstructions and lacerations may be successfully treated with retrograde or antegrade passage of a ureteral stent. Urinoma may be drained percutaneously. If a stent cannot be successfully manipulated across the lesion, a percutaneous nephrostomy should be created and plans should be made for operative repair.

SOFT TISSUE EMPHYSEMA

Subcutaneous emphysema most commonly results from periperitoneal placement of an insufflation needle or leakage of CO2 around the cannula sites, the latter frequently because of excessive intraperitoneal pressure. Although the condition is usually mild and limited to the abdominal wall, it can become extensive, involving the extremities, the neck, and the mediastinum. Another relatively common location for emphysema is the omentum or mesentery. Subcutaneous emphysema may be readily identified by the palpation of crepitus in the abdominal wall; if it extends along contiguous fascial planes to the neck, it can be visualized directly. This finding can be reflection of the development of mediastinal emphysema, which, if severe, may lead to pneumothorax and cardiovascular collapse.

Risk Reduction: Proper positioning of an insufflation needle reduces the risk of subcutaneous emphysema. No one test absolutely predicts intraperitoneal placement. A variety of tests such as aspiration, creation of pre-instillation negative pressure, and maintenance of low insufflations pressure with symmetrical distension of the abdominal wall, should be used. Pre-inflation negative pressure can be demonstrated by aspirating a drop of water placed on the open end of the insufflation needle, followed by elevation of the anterior abdominal wall. A more quantitative demonstration is to elevate the abdominal wall after the tubing is connected to the needle, the result should be alow or negative intraperitoneal pressure (-1 to 4mm Hg).

Insufflation should be initiated at a low flow rate (1 L/min) until the surgeon has

confidence that proper placement has been achieved. Loss of liver dullness should occur when about 1500 mL of gas has entered the peritoneal cavity. The distension should be symmetricaland the measured intraperitoneal pressure should be below 10mmHg, sometimes slightly higher in patients. If, at any time, the surgeon feels that the needle is not located intraperitoneally, it should be withdrawn and reinserted. After the peritoneal cavity has been insufflated with an adequate volume of gas, the primary trocar is introduced. Then the laparoscope is introduced, and if the cannula is satisfactorily located, the tubing is attached to the appropriate port.

Subcutaneous emphysema may evolve despite intraperitoneal placement of the trocars, an even that canbe avoided by maintaining low intraperitoneal pressure below 15mm Hg (preferably near 10 mmHg) after placement of the desired cannula. Other approaches that may reduce the chance of developing subcutaneous emphysema are use of open laparoscopy and the abdominal wall lifting systems that render gas unnecessary.

Management: If the surgeon finds that the initial insufflation has occurred extraperitoneally, several options exist. Removing the laparoscope and repeating the insufflation is possible, but using this method is more difficult because of the new configuration of the anterior peritoneum. Options include open laparoscopy or the useof an alternate site such as the left upper quadrant. One attractive approach is to direct insertion of the insufflation needle visually after leaving the laparoscope in the expanded preperitonealspace.

For mild cases of subcutaneous emphysema, no specific intra-or postoperative therapy is required because the findings quickly resolve after evacuation of the pneumoperitoneum. When the extravasation extends to involve the neck, terminating the procedure is usually preferable because pneumomediastinum, pneumothorax, hypercarbia, and cardiovascular collapse may result.

NEUROLOGIC INJURY

Peripheral neurological injury is usually related either to inappropriate positioning of the patient or to pressure exerted by the surgeon or assistants. Nerves may also be injured as a result of the surgical dissection.

Diagnosis: In most instances, the patient has sensory deficits, motor deficits, or both on emerging from anaesthesia. The diagnosis can usually be suspected by clinical examination. Injuries to the peritoneal nerve are reflected by loss of sensation in the lateral aspect of the leg and foot and foot-drop. Brachial plexus injuries usually involve damage to the C-5 or C-6 roots and manifest in loss of flexion of the elbow and adduction of theshoulder.

Risk Reduction: The incidence of brachial plexus injury can be reduced by placing the patient’s arms in an adducted position, which facilitates the performance of pelvic surgery and prevents the surgeon from leaning on the patient’s arm. If leaving the patient’s arm in an abducted position is necessary, adequate padding and support of both arms and shoulders should be provided. Also helpful is the use of shoulder supports to prevent slippage when the patient is placed in the Trendelenberg position.

Sciatic and peritoneal nerve injury is best prevented with the use of appropriate stirrups and careful positioning protocols. Stirrups that combine both measures include simultaneous raising and lowering of the patient's legs, flexion of the knees before flexion of the hips, and limitation of external rotation of the hip.

Management: Most injuries to peripheral nerves recover spontaneously. The time to recovery depends on the site and severity of the lesion. For most peripheral injuries, the patient recovers full sensorineural function in 3-6 months. Recovery may be facilitated with physical therapy, appropriate braces, and electrical stimulation of the affected muscles.

INCISIONAL HERNIA AND WOUND DEHISCENCE

The reports seem to indicate that defects that are 10mm or larger in diameter are particularly vulnerable, albeit no incision is immune to the risk of herniation. Another important factor contributing to risk may be the use of cannula anchoring devices that increase the diameter of the incision, sometimes as much as 3mm. Dehiscence of a laparoscopic wound may be irrelevant unless bowel or other intraperitoneal tissue herniates into and through the defect.

One of the more sinister complications, involving only a portion of the bowel wall, is Richter's hernia, which is somewhat more difficult to diagnose and may result in perforation, peritonitis, and death. The most common defect appears immediately postoperatively when bowel or omentum passes through the unopposed or inadequately repaired incision. Many defects probably remain asymptomatic, but late presentation may occur if bowel or omentum has become trapped.

Risk Reduction: Whenever possible, the smallest diameter cannula should be used; hernia has been reported in conjunction with the use of 5mm trocars. The Z-track insertion method offsets skin and fascial incisions, which potentially reduces the incidence of hernia. Another approach is to remove all ancillary cannula under direct vision to ensure that bowel is not drawn into the incision. Insertion of an obturator (or a laparoscope) into the cannula may also prevent suction from drawing bowel or omentum into the incision. Incisions 10mm or larger in diameter should undergo facial closure under laparoscopic direction to prevent incorporation of bowel, which may be accomplished by using a 5mm or smaller diameter laparoscope through one of the smaller cannula. A narrow diameter, three-quarter round needle facilitates closure, as does use of a laparoscopic ligature carrier.

Management of laparoscopic incisional defects depends on the timing of the presentation, the presence or absence of entrapped bowel, and the condition of the bowel.

Reference:

1. Jansen F W, Kapiteyn K, Trimbos-KemperT, Hermans J, Trimbos J B.

Complications of laparoscopy: a prospective multicentre observational study. Br JObstet
Gynecol. (1997);104:595–600.

2. Mayol J, Garcia-Aguilar J, Ortiz-Oshiro E, De- Diego C J, Fernandez-Represa J A. Risks ofthe minimal access approach for laparoscopic surgery: multivariate analysis of morbidity related to umbilical trocar insertion. World J Surg.(1997);21:529–533.

3. Nuzzo G, GiulanteF, TebalaG D, Vellone M, Cavicchione C. Routine use of opentechnique
in laparoscopic operations. J Am Coll Surg. (1997);184:58–62.

4. Hackam D J, Rotstein O D. Host response to laparoscopic surgery: mechanisms andclinical correlates.CanJSurg41.(1998);(2):103–111.

5. OrtegaAE,PetersJH,IncarboneR,EstradaL, Ehsan A, Kwan Y, Spencer C J, Moore-Jeffries E, Kuchta K, Nicoloff J T. A prospective randomized comparison of the metabolic and stress hormonal responses of laparoscopic and open cholecystectomy. J AmColl
Surg. (1996);183:249–256.

6. GlerupH,HeindorffH,FlyvbjergA,JensenS L, Vilstrup H. Elective laparoscopic cholecystectomy nearly abolishes the postoperative hepatic catabolic stress response. Ann Surg.(1995);221(3):214–219.

7. Patel M I, Hardman D TA, Nicholls D, Fisher C M, Appleberg M. The incidence of deep venous thrombosis after laparoscopic cholecystectomy. MedJ Austral. (1996);164:652–656.

8. McLaughlin J G, Scheeres D E, Dean R J, Bonnell B W. The adverse hemodynamiceffects of laparoscopic cholecystectomy.Surg
Endosc. (1995);9:121–124.

9. Dorsay D A, Greene F L, Baysinger C L. Hemodynamic changes during laparoscopic cholecystectomy monitored transesophageal echocardiography.SurgEndosc.(1995);9:128– 134.

10. Koksoy C, Kuzu M A, Kurt I, Kurt N, YerdelM A, Tezcan C, Aras N. Haemodynamiceffects of pneumoperitoneum during laparoscopic cholecystectomy: a prospective comparative study using bioimpedance cardiography. Br J Surg.(1995);82:972–974.

11. JorisJL,ChicheJ-D,CanivetJ-LM,Jacquet N J, Legros J JY, Lamy M L. Hemodyna-mic changes induced by laparoscopic and their endocrine correlates: effects of clonidine. J Am Coll Cardiol.(1998);32(5):1389–1396.

12. Russell J C, Walsh S J, Mattie A S, Lynch JT. Bile Duct Injuries, 1989–1993.Arch

Surg. (1996);131:382–388.

13. Moore M J, Bennet C L. TheSouthern Surgeons Club. The learning curve for laparoscopic cholecystectomy. Am J Surg.(1995);170:55–59.

14. Z'Graggen K, Wehrli H, Metzger A,Buehler M, Frei E, Klaiber C. Complications of laparoscopic cholecystectomyin Switzerland. Surg Endosc. (1998);12:1303– 1310.

15. Lee V S, Chari R S, Cucchiaro G, MeyersW C. Complications of laparoscopic cholecystectomy. Am J Surg. (1993);165:527–532.

16. ViljakkaM T, Luostarinen M E, Isolauri J O. Complications of open and laparoscopic antireflux surgery: 32-year audit at a teaching hospital. J Am Coll Surg.(1997);185:446–450.

17. LeggettPL,Churchman-WinnR,AhnC. Resolving gastroesophageal reflux with laparoscopic fundoplication.Surg Endosc. (1998);12:142–147.

18. Peters J H, DeMeester T R, CrookesP, Oberg S, de Vos Shoop M, Hagan J A, Bremner C G. The treatment of gastroesophageal reflux disease with laparoscopic Nissen fundoplication. Ann Surg. (1998);228(1):40– 50.

19. TrusT L, Laycock W S, Wo J M, Waring JP, Branum G D, Mauren S J, Katz E M, HunterJ G. Laparoscopic antireflux surgery in the elderly. Am J Gastroenterol. (1998);93(3):351– 353

20. Eshraghi N, Farahmand M, Soot S J, Rand- Luby L, Deveney C W, Sheppard B C. Comparison of outcomes of open versus laparoscopic Nissen fundoplicationperformed in a single practice. AmJ Surg. (1998);175(5):371–374

21. Harris S C. Laparoscopic antirefluxsurgery. Am J Surg.(1996);171(5):482–484.

22. Richards K F, Fisher K S, Flores J H, Christensen B J. Laparoscopic Nissen fundoplication: cost, morbidity, andoutcome compared with open surgery. Surg LaparoscEndosc. (1996);6(2):140–143.

23. VoitkA. The learning curve in laparoscopic inguinal hernia repair for the communitygeneral surgeon. Can J Surg.(1998);41(6):446–450.

24. KiruparanP, Pettit S H. Prospective audit of 200 patients undergoing laparoscopic inguinal hernia repair with follow-up from 1 to 4 years.J Royal Coll Surg Edinb.(1998);43:13–16

25. Leibl B J, Schmedt C G, Schwarz J, DaublerP, Kraft K, Schlossnickel B, Bittner R. A single institution's experience with transperitoneal laparoscopic hernia repair. AmJ
Surg. (1998);175(6):446–451.

26. Litwin D E M, Pham Q N, Oleniuk F H, KluftingerAM,RossiL.Laparoscopicgroin hernia surgery: the TAPP procedure. Can J Surg.(1997);40(3):192–198.

27. Wellwood J, Sculpher M J, Stoker D, Nichills G J, Geddes C, Whitehead A, Singh R, Spiegelhalter D. Randomized controlled trialof laparoscopic versus open mesh repair for inguinal hernia: outcome and cost. BrMed
J. (1998);317(7151):103–110.

28. Zieren J, Zieren H U, Jacobi C A, Wenger FA, Muller J M. Prospective randomized study comparing laparoscopic and open tension-free inguinal hernia repair with Shouldice's operation. Am J Surg.(1998);175(4):330–333.

29. Slim K, Pezet D, Chipponi J. Laparoscopicor open appendectomy: clinical review of randomized controlled trials. Dis Colon &
Rectum.(1998);41(3):398–403.

30. Garbutt J M, Soper N J, Shannon W D,Botero A, Littenberg B. Meta-analysis of randomized controlled trials comparing laparoscopic and open appendectomy. SurgLaparosc
Endosc. (1999);9(1):17–25.

31. HellbergA,RudbergC,KullmanE,Enochsson L, Fenyo G, Graffner H, Hallerback B, Johansson B, Anderberg B, Wenner J, Ringqvist I, Sorensen S. Prospective randomized multicentre study of laparoscopic versus open appendicectomy.BrJSurg.(1999);86:48–53.

32. Kluiber R M, Hartsman B.Laparoscopic appendectomy: a comparison with open appendectomy. Dis Colon&
Rectum. (1996);39(9):1008–1011

33. Lumley J W, Fielding G A, Rhodes M, Nathanson L K, Siu S, Stitz RW. Laparoscopic- assistedcolorectalsurgery:lessonslearnedfrom 240 consecutive patients. Dis Colon&
Rectum. (1996);39(2):155–159

34. Lord S A, Larach S W, Ferrara A, Williamson P R, Lago C P, Lube M W. Laparoscopic resectionsforcolorectalcarcinoma:athreeyear experience. Dis Colon& Rectum. (1996);39(2):148–154

35. Kwok S P Y, Lau W Y, Carey P, Declan K, Seamus B, Leung K L, Li A K C. Prospective evaluation of laparoscopic-assistedlarge-bowel excision for cancer.Ann
Surg. (1996);223(2):170–176.

36. Bennett C L, Stryker S J, Ferreira R M,Adams J, Beart R W. The learning

curve for laparoscopic colorectal surgery: preliminary results from a prospective analysis of 1194 laparoscopic-assisted colectomies.Arch
Surg. (1997);132(1):41–45.

37. Reissman P, Salky B A, Pfeifer J, Edye M, Jagelman D G, Wexner S D. Laparoscopic surgery in the management of inflammatory bowel disease. Am J Surg.(1996);171(1):47–51.

Chapter:10

LAPAROSCOPY DURING PREGNANCY

EXCERPTS FROM SAGES MANUAL

Introduction:

Initially pregnancy was considered an absolute contraindication to laparoscopic surgery. Recent clinical reports have demonstrated the feasibility, advantages and potential safety of laparoscopic surgery in the pregnant patient. However, concerns about effects of carbon dioxide pneumoperitoneum on mother and fetus persists, resulting in controversy and concern.

Two new considerations and challenging complexities to the issue. First, involves the altered physiology of the pregnancy condition that may change the biologic response to carbon dioxide pneumoperitoneum and position extremes. Second, involves the effects on the foetus which maintains the physiology distinct from that of adults. That can cause foetal acidosis and hypoperfusion.

The safest time to operate on the pregnant patient is during 2^{nd}trimester because risks of teratogenesis, miscarriage and preterm delivery are lowest. The incidence of spontaneous abortion is highest in the1^{st}trimester that is 12%, decreasing to 0% by the 3^{rd}.

During the 2^{nd}trimester there is 5 to 8% of preterm labour and premature delivery which increases to 30% in the 3^{rd} trimester. Finally the gravid uterus is not yet large enough to abscure the operative field as in the case during the 3^{rd} trimester.

Advantages and feasibility of Lap. Surgery during pregnancy:

Potentially, laparoscopic surgery in the pregnancy patient should result in the proven advantages of laparoscopy seen in the nonpregnant patient like decreased pain, earlier return of gastrointenstinal function, earlier ambulation, decreased hospital stay and faster return to routine activity. In addition, a decreased rate of premature delivery due to decreased uterine manupulation, decreased foetal depression secondary to decreased narcotic usage and a lower rate incisional hernia may be seen in the pregnant patients.

Disadvantages and concerns about lap. Surgery during pregnancy:

Concerns about lap. Surgery in pregnant patients center on three areas.

- Increased intraabdominal pressure can lead to decreased inferior venacaval return resulting in decreased cardiac output. The foetus is dependent on maternal haemodynamicstability. The primary cause of foetal demise is maternal hypotension or hypoxia. So a fall in maternal cardiac output could result in foetal distress.
- The increased intraabdominal pressure seen with a pneumoperitoneum could lead to decreased uterine bloodflow and increased intrauterine pressure. Both of which could result in foetal hypoxia.
- Carbon dioxide is observed across the peritoneum and can lead respiratory acidosis

in both mother and the fetus. Fetal acidosis could be potentiated by the decreased venacaval return.

Biliary tract disease:
Gallstones are present in 12% of all pregnancies and cholecystectomy is performed in 3 to 8 out of 10,000 pregnancies.

- An uncomplicated open cholecystectomy in pregnant patient should be accompanied by a 0% maternal mortality, 5% foetal loss and 7% preterm labour.
- Complications such as Gallstone pancreatitis or acute cholecystitis will increase maternal mortality to 15% and foetal demise to 60%.
- Patients with uncomplicated biliary colic should be treated medically with non fat diets and pain medications until after delivery. Patients who present in the 1st trimester of pregnancy with crescendo biliary colic or persistant vomiting should be medically managed if possible until they are in the 2nd trimester. Pregnant patient in the 2nd trimester of pregnancy who present with the above complications of biliary tract disease will need operative treatment during the2nd trimester after appropriate resuscitation. Patients with these complications who present in the 3rd trimester of pregnancy should be treated conservatively until after delivery if possible or atleast until a gestational age of 28-30 weeks in order to maximized foetal viability.

Clinical Studies:
One clinical study has reported four fetal deaths following laparoscopic surgery. Three occurred during first post operative week and the last four weeks post operatively. The causes of death are unknown but might be related to prolonged operative time. The operative times in these four patients was 106 minutes compared to the average of 55 minutes seen in the other studies. The laparoscopic procedure was performed for pancreatities in three of these women and a perforated appendix in the forth. It is possible that foetal loss was the result of the inflammatory process itself rather than laparoscopy per se. There is a 4% foetal mortality rate for all reported. laparoscopic cholecystectomies. It compares favourably with a 5% foetal mortality rate seen with open procedures.

One study has retrospectively compared pregnancy patients undergoing open laparotomy to pregnant patients undergoing laparoscopic surgery and found the later resumed regular diet earlier, required less pain medication and were hospitalized for shorter time. These differences were statistically significant.
Another clinical study revealed 150 laparoscopic cholecystectomies in pregnancy patients. Averageoperative time 55 minutes and average length of stay was 1.3 days. There were no reports of maternal complications or death. Of 99 babies delivered at the time of publication, three werepremutureandonewasbornwithhyalinemembrane disease at 37 weeks gestation. The remaining 95 were fullterm and healthy. There were no intraoperative foetal deaths or complications.

Animal Studies:
Animal studies raise several concerns about the effects of a carbon dioxide pneumoperitoneum on the mother and fetus. Because of the complexity of the maternal-fetal unit, it is useful to summarize these individually:

1. In pregnant baboons, a carbon dioxide pneumoperitoneum held at 20 mm Hg pressure for 20 mitutes resulted in increased pulmonary capillary wedge pressure, pulmonary artery pressure and central venous pressure. The mothers developed a respiratory acidosis despite controlled ventilation and an increase in respitatory rate. One fetus developed severe bradycardia which responded to desufflation.

2. In pregnant ewes, no change in maternal placental blood flow was seen after 2 hours of 13 mm Hg pressure. However, maternal and fetal respiratory acidosis developed. Fetal tachycardia, fetal hypertension, an increase in intra-uterine pressure and a decrease in uterine blood flow were also seen in pregnant ewes undergoing a carbon dioxide pneumoperitoneum at 15 mmHg.

3. Maternal respitatory acidosis and severe fetal respiratory acidosis are common findings in all studies utilizing a carbon dioxide pneumoperitoneum in pregnant animals. Changes in respiratory rate did not completely correct the problems. Despite these problems. One study demonstrated that the ewes delivered fulterm healthy lambs following intraabdominal unsufflation to 15mm Hg pressure with carbon dioxide for one hour.

4. The physiologic changes exhibited by the pregnant ewe and fetus during insufflation, with carbon dioxide are nor present with nitrous oxide. Fetal tachycardia, hypertension, and acidosis as well as maternalacidosis are not present when utilizing a nitrous oxide pneumoperitoneum in animal studies. Use of nitrous oxide as an insufflating gas in the pregnant womanhas yet to be evaluated, but may prove to be safer than carbon dioxide.

Guidelines:
The following practices should be followed when performing laparoscopic surgery in the pregnant to minimize adverse effects on the fetus or mother. More information is given in the SAGES Guidelines for Laparoscopic Surgery During Pregnancy:

1. Place the patient in the left lateral decubitus positionas with open surgery to prevent uterine compression of the inferior vena cava. Minimizing the degree of reverse Trendekenburg position may also further reduce possible uterine compression of the venacava.

2. Use antiembolicdeviceto prevent deep venous thrombosis. Stasis of blood in the lower extremities is common in pregnancy. Levels of fibrinogen and factors VII and XII are increased during pregnancy leading to an increased risk of thromboembolic events. These changes, coupled with the decreased venous return seen with increased intraabdominal pressure and the reverse Trendelenburg position used during laparoscopic surgery, significantly increase the risk of deep venous thrombosis.

3. An open Hasson technique for gaining access to the abdominal cavity is

safer than a closed percutaneous puncture. Several authors have inserted a Verres needle in the right upper quadrant without complications, but the potential for puncture of the uterus or intestine still sxists, especially with increasing gestational age.

4. Maintain the intraabdominal pressure as low as possible while still achieving adequate visualization. A pressure of less than 12-15 mm Hg should be used until concerns about the effects of high intraabdominal pressure on the foetus are answered.

5. Continuously monitor maternal end tidal CO2and maintain it between 25-30 mm by changing the minute ventilation. Promptly correcting any evidence of maternal respiratory acidosis is critical as the fetus is typically slightly more acidotic than the mother

6. Use continuous intraoperative fetal monitoring. If fetal distress is noted, release the pneumoperitoneum immediately. Monitoring should be used even if the fetus is not viable, as the desufflation may reverse fetal distress, preventing serious problems. Transabdominal ultrasound fetal monitoring may not be effective because the establishment of the pneumoperitoneum may decrease fetal heart tones, so intravaginal ultrasound may be necessary for intraoperative monitoring.

7. If intraoperative cholangiography is to be performed protect the fetus.

8. Minimize operative time. Several studies have demonstrated a correlation between the duration of a carbon dioxide pneumoperitoneum and an increase in PaCO2.

9. Tocolytic agents should not be administered prophylactically, but are appropriate if there is any evidence of uterine irritability orcontractions.

10. Trocar placement:

(a) Biliary tract disease: Place a Hasson trocar above the umbilicus. Place the remaining ports under direct visualization in the usual locations.

(b) Appendicitis/ diagnostic laparoscopy: Place a Hasson trocar in the subxiphoid region. Insert the camera and locate the appendix or other inflammatory process. Insert the remaining trocars in locations appropriate to the pathology. For appendicitis,this will usually be the right upper quadrant at the costal margin and in the right lower quadrant. Occasionally an additional port might need to be placed just above the uterus. If the uterus is too large and appendectomy cannot be performed laparoscopically, then laparoscopic visualization of the appendix may help determine the best location for the open incision.

Conclusion:

In conclusion, animal studies indicate that a carbon dioxide pneumoperitoneum causes fetal acidosis which may not be corrected by changes in maternal respiratory status. These intraoperative findings do not appear to have any long term adverse effects on the fetus. The pregnant patient clearly benefits from laparoscopic surgery

and should be offered this option as long as the above guidelines are followed.

References:

THE SAGES MANUAL, Fundamentals of laparoscopy and GI Endoscopy SAGES, SocietyAmerican, Gastrointestinal, Endoscopic Surgeons98-103.

Mastery of Endoscopic and laparoscopic surgery, Edited by W.StephenEubanks, Lee L. Swanstrom, Nathaniel J.Soper.

Abuabara SF, Gross GW, Sirinek KR Laparoscopic cholecystectomy during pregnancy is safe for both mother and fetus. J Gastrointest surg 1997; 1:48-52.

Amos JD, Schorr SJ, Norman PF, poole GV, Thomae KR, Mancino AT Hall TJ, Scott Conner CEH. Laparoscopic surgery during pregnancy. Am J Surg 1996; 171:435-437 Barmad JM, Chaffin D, Drose S,Tierney A, Phernetton T. Fetal response to carbon dioxide pneumoperitoneum in the pregnant ewe. ObstetGynecol1995;85:669-674.

Curet MJ, Vogt DM, Schob O, Qualls C, Izquerdo LA, Zucker KA. Effects of CO2 Pneumoperitoneum in pregnant ewes. J Surg Research 1996; 63:339-344.

Curet MJ, Allen D, Josloff RK, Pitcher DE, Curet LB, Miscall BG, Zucher KA. Laparoscopy during pregnancy. Arch Surg 1996; 131:546-551.

Hunter JG, Swanstrom L, Thornburg K, Carbon dioxide pneumoperitoneum induces fetal acidosis in a pregnantewe model. Surg Endose1994;4:268-271.

Kammerer WS. Nonobstetric surgery during pregnancy. Med Clin North Am 1979;63:1157-1163.

Mckellar DP, Anderson CT, Boynton CJ, Peoples JB, Cholecystectomy during pregnancy without fetal loss. Surg GynecolObstet1992;174:465-468.

Motew M, Ivankovich AD,Bieniarz J, Albrecht RF, Zahed B, ScomegnaA.Cardiovascular effects and acid-base and blood and blood gas changes during laparoscopy. Am J ObstetGyncol 1973 113:1002-1012.

Reedy MB, Galan HL, Bean JD, Carnes A, Knight AB, Juehl TJ. Laparoscopic insufflation in the gravid baboon:maternal and fetal effects.J Am Assoc Gynecol Laparoscopist 1995;2:339-406. Soper NJ, Hunter JG, Petri RH. Laparoscopic cholecystectomy in the pregnant patient. Surg LaparoscEndosc1994;4:268-271.

Chapter:11

PRINCIPLES OF LAPAROSCOPIC ORGAN RETRIEVAL

Advances in laparoscopic techniques have allowed detachment of almost any intra abdominal organs from their original sites.

Small specimen can be removed easily via the trocar. Any specimen larger than the diameter of the conventionally used trocar can however, prove difficult to remove and needs a special method for its removal. There are several techniques to remove specimens. Removal methods depend on the size, location and nature of specimen whether it is infected, malignant, chorionic tissue, endometriotic or dermoid. In all these situations endobag is used for removal.

Removal of large volumes of tissue from the abdomen can be the most time consuming and frustrating part of the operation sometimes it may be more difficult than the operation itself.

Ideally the site selected for specimen removal should be along the path of least resistance that produces the least pain, prevents contamination, and provides the best cosmesis. If a specimen cannot be removed from the abdominal cavity immediately after it has been resected, it must be secured in a position that will permit ready identification and retrieval later.
Ex: Ut-vesical pouch or POD is an endobag or against abdomen wall with a suture.

Several potential routes for removal of abdominal and pelvic specimens are

- Port Sites
- Separate abdominal wall incisions
- Transanal (if colon resection performed)
- Transvaginal (via culpotomy incision)

1. Small Specimens: Can be removed directly through an appropriate cannula (Usually 10mm or larger) with or without a reducing sleeve. Use a toothed grasper to secure the specimen as it is retrieved under direct laparoscopic visualization and control. Open the valve mechanism of the cannula to allow the specimen to pass through unimpeded, if a reducting sleeve is not used.

2. Specimens at the port site by several methods:

a. Reduce the size of the specimen while it is still within the peritoneal cavity: that is, remove contents of hollow structures (fluid stones) or cut up solid structures. This technique permits removal without enlarging the incision. The major disadvantages include the risk of losing portions of the specimen and contamination of the peritoneal cavity. This method may be appropriate for the removal of specimens such as lymph node packets and benign solid tumors of moderate size.

b. Exchange the existing cannula for a larger cannula at the port site (20-40mm),

by placing it over a blunt probe with a tapered introducer. This method protects the wound from direct contact with the specimen. A major disadvantage is that the specialized cannulae are not always available. This method is sometimes used for removal of specimens such as an inflamed appendix, gallbladder, fallopian tube, andovary.

c. Exteriorize portions of the specimen and then remove the contents so that the specimen can be pulled through the port site. This is most commonly used for removal of the gallbladder following laparoscopic cholecystectomy. Hold the specimen firmly against the end of the cannula as both are pulled our together under laparoscopic visualization. Grasp a portion of the gallbladder outside of the abdomen with clamps and open the gallbladder. Aspirate fluid, and remove stones (Fragmenting them if necessary) with stone forceps or ring forceps. This technique avoids enlarging the incision and requires. No special equipment. However, it risks wound contamination and is tedious if the stones are multiple or large.

d. Enlarge the incision at a port site. This is perhaps the simplest, most commonly used method in many circumstances. It works particularly well at umbilical or other midline port sites since only a single fascial layer requires division. Either stretch the fascia or elevate it with a right-angled clamp and divide it with scissors or a scalpel. Perform this maneuver under direct laparoscopic visual control, with the specimen held in a relaxed manner (not taut against the abdominal wall) to avoid punctuating the specimen. This is frequently the best method of removing a large, stone-filled gall bladder.This is also the typical method for removing larger organs such as the colon and spleen. The length of incision necessary in these cases varies but so usually only several centimeters. When the port site incision is not midline, use a muscle spreading technique to avoid dividing abdominal wall musculature.

During colectomy the colon is often exteriorized through an extended port site incision prior to complete resection. After resection the anastomosis can be extracorporally. These are considered “laparoscopically assisted operations”.
A disadvantage of this technique is the loss of pneumoperitoneum that occurs during specimen extraction. To reestablish the pneumoperitoneum, completely close the incision if that port site is no longer needed. Alternatively, close or tighten the fascia around a cannula.
Another disadvantage of incision enlargement forspecimen retrieval is the increased discomfort that patients may have at that site. Regardless, this is often the most practical method.

3. Separate abdominal wall incision. In some situations it may be most practical to remove the specimen through a separate abdominal wall incision that doesnot incorporate any of the existing port sites. These incisions can generally be limited to a few centimeters in length, and a muscle-splitting technique can be used for non-midline sites. Examples of this technique include removal of the right or left colon through transverse incisions lateral to the rectus in the right or leftabdomen, respectively, removal of colon through a suprapubic or lower abdominal incision, and removal of an intact spleen through a low midline or Pfannenstiel incision. During colon resection the site of incision can gauged by holding the mobilized

specimen up to the abdominal wall; this location may or may not correspond to an existing cannula site.

4. **Transanal route.** Transanal extraction has been used for some laparoscopic low anterior colon resections. This route can be considered when the lower limited of transection is near or below the pelvic brim and the specimen is not too bulky. Place the specimen is a bag. Slowly dilate the anus and pass a ring forceps or similar instrument transanally. Grasp the bag and gently pull it through the rectal stump and anus. During laparoscopic abdominperineal resection the specimen is readily delivered through the perineal incision in a similar manner.

5. **Transvaginal route.** Another alternative to abdominal incision for intact removal of larger specimens is an incision in the posterior vaginal fornix (cul de sac), which is termed coldotomy or posterior colptomy. This has most frequently been used for removal of ovarian masses, fibroids or the uterus during laparoscopic-assisted vaginal hysterectomy and occasionally for other solid organs.

RETRIEVAL BAGS

Retrieval Bags are-Commercially manufactured bags and retrieval devices are Disposable, Expensive, Not freely available.

Devices:
Olympus key med- 5 mm, 15mm, 20mm tubes.

Extraction bags:
storz-germany
Lap Sac-cook UK
Endo catch-Autosuture

Use of a specimen retrieval bag minimizes the risk of contamination and specimen loss.
This is particularly important when the specimen may be infected, malignant friable or leaking or chorionic tissue or endometriotic tissue.

The important features to consider in selecting a retrieval bag are its strength, size, aperture, maneuverability, ease of deployment and retrieval, and porosity. Bags are typically made of polyurethane and are preferred for removing larger specimens that must be fragmented in the bag, such as the spleen or kidney.

There are several common principles

Bag insertion:
Tightly roll the bag and insert it through the cannula. Bag deployment:
Pull the bag gently our of the cannula site to unroll it. Grasp the edges of the bag and open the month by pulling in opposite directions. Third instrument may be necessary to help open thebag.

Specimen entrapment:

This is the most difficult step particularly for large organs. Hold the mouth of the bag open with graspers, advance the grasper holding the specimen all the way to the depth of the bag. The specimen should enter the bag and the entire specimen must fit within the bag prior to closure.

Bag closure:
Commercial bags are equipped with a draw string that must be tightened. Close the small plastic bags with a preformed endoscopic ligature.

Bag extraction:
Under constant visual control with draw the bag and cannula through the abdomen wall as a unit.
Small bags comes our through 10 to 12mm port.
The Big bag and the contained specimen are removed by wither enlarging the port or by reducing the specimen size by removing portions or fragment org.
Resist the temptation to pull hand and use care to avoid punching or tearing the bag.

In Our institution we use condoms, Sterile plastic bags as endobags.
These endobags are-
Economical
Easily avaiable
Electronically tested
Easy to introduce through the 10mm port
Easy to put the specimens
Easy extraction

Morcellator

Devices exist for both manual and mechanical morcellation. The hand operated Tissue punch (Storz, Tuttlingen, Germany), first described by semm in 1978 takes bites of tissue, which are pushed up the 11mm diameter shaft of the instrument. It is said to beinadequate for large tissue volumes and unable to deal with firm or calcified specimens (Steiner et al.,1993).

Two devices are currently available that will mechanically morcellate large volumes of tissue. The cook Tissue Morcellator (Cook UK) Letchworth, UK), was first described for the laparoscopic removal of a 190g tumor- bearing kidney through an 11mm port by Clayman et al. in 1991. The disposable morcellator is connected to areusable power unit and a suction supply.

The tissue for removal needs to be placed in an isolating bag, the mouth of which pulled through the abdominal wall. The cutting cannula is then placed into the bag. Using the foot switch the specimen is then morcellated and aspirated from within thebag.

The Steiner electromechanical Morcellator (Storz, Turrlingen, Germany) is shown in 1993, this reusable device allows morcellation inside the abdomen under laparoscopic observation. The instrument has a motor driven cutting tube that is 13mm in diameter. After inserting the tube, claw forceps are passed down the shaft to grasp the specimen. Using a foot switch the tube is thenrotated while pulling the

specimen against the mouth of the tube. Cylinders of tissue are cut, which are pulled up the shaft and are suitable for histologic examination. The speed and direction of rotation of the tube can bevaried.

With the potential for severe trauma to intraabdominal organs certain precautions are recommended.
. Only adequately trained surgeons should use the device, which should always be correctly maintained and functioning properly.
. The rotating cylinder should only be in motion when under continous visual control.
. The sharp tip should be maintained in the same position within the abcomen at all times.
A new version of this device is equipped with a springloaded retractable trocar sleeve, which covers the cutting edge of the cylinder.
Large volumes of tissue that need isolation before removal can be placed within one of the largerlaparoscopic bags. Suitable specimens include ovarian teratomasand mucinous cysts, and any ovary that may be neoplastic. Errors in laparoscopic assessment of ovarian cysts are well documented (Maiman et al.,1991). Others have shown that with strict adherence to guidelines of preoperative ultrasound assessment and intraoperative inspection, laparoscopic management of adnexal cystic masses appears to be safe (Mage et al., 1990).

Indeed some new surgeons advocate laparoscopic management of stage 1A and B ovarian carcinoma (Reichet.,1990).
Once inside a bag cystic messes can be decompressed by incision and aspiration of their contents. This can be done inside the abdomen or after pulling the mouth of the bag outside the abdominal wall. Although malignant tumors can be safely removed using aspiration and morcellation with the mouth of the bag outside the abdomen (Clayman et al., 1991), some authors are against this technique for suspicious masses, advocating intact extraction using a bag and an enlarged abdominal or colpotomy incision (Canis et al.,1994).

Complications

1. IncisionalHernia
Risk increase with the size of incision even if attempts are made to close the facial defect.
It is more common with laterally placed ports.

2. **PosteriorColpotomy**:-
. Infection
. Dyspareunia
. Adhesion formation
. Rectal injuries
. Ureteric Injury
3. Spillage-
. Residual trophoblastic tissue.
. Endometiosis can implant in the abdomen wall scar endometriosis

. Dissimination of malignant cells.
. Fecal contamination can occur during appendicectomy.
. Spillage of contents of a mucinous cyst adenoma may cause Pseudomyxoma peritoneum

. Chemical peritonitis and granuloma formation with intestinal obstruction have been reported after laparoscopic surgery for Dermoid cyst ofovary.

4. **Specimens may be lost** in the abdominal cavity. It may be possible to recover the lost specimens by filling the upper abdomen with the saline and patient in the trendelenburg position and then reversing the position

5. **Vascular injury** during enlarging the portsite.

6. **Condoms-** The potential risksinclude:

- Question able asepsis
- Latex anaphylaxis
- Splitting and fragmentation of the condom

Conclusion:

With patience and ingenuity the specimens generated by operative laparoscopy can be removed without resorting to enlarged incisions, through the port sites or by culdotomy by using easily available condoms or plastic bags.

Reference:

1. Complications of laparoscopy andHysteroscopy 1998 secondedition.
Randle S. Corfman; MD
Michael.P. Diamond, MD
Alan H. Decherney, MD

2. Endoscopic Surgery for Gynaecologists
Second edition 1997 Edited by
- ChrisSutton
University of London UK
- Michael P.Diamond
Detroit USA
Wayne State University School of Medine

2. The SAGES Manual1999 fundamentals of laparoscopy and GIEndoscopy

Carol E.H. Scott-ConnerMD,PhD, University of Iowa Hospitals and Clinic

Chapter:12

PORT PLACEMENT IN LAPAROSCOPY

In laparoscopy we routinely use five and ten mm ports. Of these the first two insert is called the primary or the camera port. The secondary ports vary in number depending on the type of surgery. An accessory secondary port may be required if the case is difficult in order to retract bowel or other viscera to enable visualization and proper identification of the anatomy.

For all practical purposes, the primary port hover around the umbilicus, as it marks the centre of the peritoneal cavity and all structures can be well focused and reached from this spot. Moreover, all the layers of the fascia converge at the umbilicus and the distance between the skin and the anterior peritoneum is leased here. But for anatomical reasons, e.g. in a patient with umbilical hernia the primary port can't be place around the umbilicus, and secondly if there are scars in the vicinity of the umbilicus due to previous surgeries, the primary port is placed at alternate points ; the commonest being the palmers point.

Other points which can be used for the introduction of the primary port are the right hypochondrium, suprapubic region and rarely the right iliac fossa. Now, all that wehave discussed stands good when we are dealing with an intraperitoneal organ. And more or less a sort of standization is reached while deciding ports for surgery on an intraperitonealorgan.

Some organs can be approached both intraperitoneally as well as extra peritoneally, so do some surgeries. So, in these cases the ports are placed in the respective intraperitioneal or extraperitoneal spaces. Now standardization for placing these ports has not been achieved and placement of these ports mainly depends on individual preferences and there is not much choice as these spaces are limited, and are not huge like the peritonealcavity.

Consideringanorgan, e.g. adrenalgland, which can be approached both intra-peritoneally and retroperitoneally, the decision is made based on the disease involving it. E.g. phaeochromocytoma – intraperitoneal, or if the gland is large or if it is suspected to be malignant, then also theintra peritoneal source is taken. In other cases, retroperitoneal route is preferred – reasons for which are given point wise. Another example which I can think of is the inguinal hernia, which can be approached both, by the intra and extraperitoneal routes. Of course the choice is made on factors like the type of hernia, previous surgery etc.

Advantages of retroperitoneal approach.

1. Peritoneal cavity is not entered so there are not chances of formation of postoperative adhesions at a later date.
2. There is no risk of contamination of the peritoneal cavity by the contents of the urinary tract.
3. There is less risk of injury to the intraperitoneal organs.
4. There is no need for retraction of intraabdominal visceras.
5. There is no ileus in the postoperative period andhence faster convalescence as there is no need to mobilize the gut to expose the urinary tract.

6. No need to change the position of the patient after creating pneumperitoneum like in nephrectomy.
7. As most organs are retroperitoneal access to the siteof lesion is direct.
8. Less trocar punctures are needed as there is less requirements for retraction.
9. It is safe even in patents with history of previous intraperitoneal surgeries.
10. Less incidence of bowel herniation than with transperitoneal approach.

Disadvantages of retroperitoneal approach

1. Less space is available to perform the surgery.
2. There are few landmarks in the retroperitoneum. More experience and longer learning curve is needed for this approach.
3. There are reports that suggest that there is greater absorption of CO^2 by this route and a higher incidence of pneumothorax or pneumomediastinum.
4. This space is sometimes obliterated in patients with inflammatory pathologies like pyelonephritis.
5. Large tumour mass does not all its free manipulation.

Advantages of transperitoneal approach.

1. More space is available to perform the surgery.
2. The anatomical landmarks are easy to identify and therefore shorter learning curve.
3. Large tumour masses are easy to manipulate in the large peritoneal space.

Disadvantages of transperitoneal approach.

1. Chances of formation of intraabdominal adhesions at a later date.
2. Contamination of the peritoneal cavity by ruinous contents.
3. Risk of injury to intraperitoneal organs.
4. Requires longer operative time.
5. Risk increases in patients with previous history of intraperitoneal surgery.
6. More chances of bowel herniation than with the retroperitoneal approach.

<u>Ports for laparoscopic cholecystectomy.</u>

Primary port - 10 mm
subumbilical / transumbilical.

Secondary ports – 5 mm subcostal in the anterior axillary line
5 mm subcostal in the mid clavicular line
10 mm epigastric region to the right of the falciform ligament.

Accessory port - 5 mm or 10 mm
3 to 4 cm above and to the left of the umbilicus.

<u>Ports for laparoscopic appendecectomy.</u>

Primary port - 5 mm
Subumbilical

Secondary ports - 10 mm suprapubic
5 mm left iliac fossa for pelvic position
Right hypocondrium for paracaecal position
Right iliac fossa for retrocaecal position.

If

Primary port – 10 mm

Subumbilical

Secondary ports - 5 mm suprpubic
5 mm left iliac fossa for pelvic position
Right hypocondrium for paracaecal position
Right iliac fossa for retrocaecal position.

Ports for laparoscopic assisted appendecectomy.
Primary port - 5 mm / 10 mm
Subumbilical
Secondary port - 7 mm / 10 mm
Right iliac fossa.

Ports for LAVH
Primary Port - 10 mm
Subumbilical
Secondary Ports - 5 mm suprapubic
5 mm right/left iliac fossa
Accessory Port - 5 mm
3 to 4 cm above and right/left of the umbilicus.

Ports for Ovarian cystectomy
Primary Port - 10 mm
Subumbilical
Secondary Ports - 5 mm suprapubic
5 mm right iliac fossa
5mm left iliac fossa

Ports for laproscopic myomectomy
Primary port - 10 mm
Subumbilical
Secondary ports - 5 mm suprapubic
5 mm right iliac fossa
5mm left iliac fossa.

Ports for Nissen's Fundoplication.
Primary port - 10 mm
3 to 4 cm above and left of the umbilicus
Secondary ports - 5 mm epigastric port replaced by liver retractor.
10 mm left subcostal in the mid clavicular line
10 mm right subcostal mid clavicular line.
5 mm left subcostal in the anterior axillary line.

Ports for laparocopic TAPP
Primary port - 10 mm
Subumbilical
Secondary port - 5 mm left flank 1 to 2 cm below the umbilicus
5 mmright flank 1 to 2 cm below the umbilicus

Ports for laparocopic TEP

Primary port -	10 mm Below and to the right or left of the umbilicus
Secondary ports	5 mm suprapubic 5 mm between suprapubic and primary port.