Harmonic scalpel and surgery, Spotlights !

By

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Why Know this type of material?

- If it can harm the patient or kill you as an employee, then it might be of benefit to learn about the physics behind the devices and gain a conceptual grasp of how things work and why.

In operative laparoscopies we often use electricity either to cut, desiccate or coagulate; but major catastrophes may arise if non targeted tissue is injured.

So before we use this tool it is wise to know some basics about electrocautery, ultrasonic dissector,...etc, and how to avoid its dangers.

Electricity

almost always searches for a conductor to reach the ground

Alternating current

60 HZ → House hold current → Faradic effect resulting in cardiac arrest

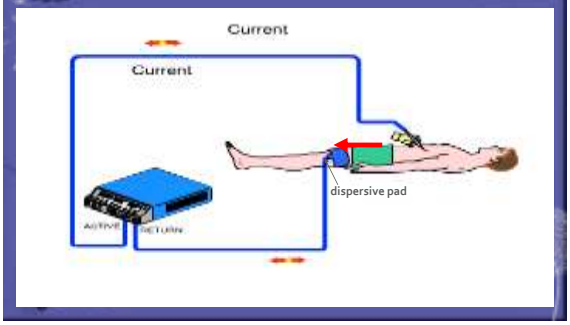
Below 100 KHz → Neuromuscular stimulation

Above 350 KHz → Radio frequency and used in ESU → thermal effect

Electrosurgical unit

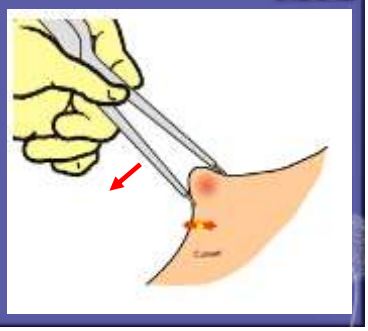
Convert standard electrical frequencies from the wall outlet, which are 50 to 60 Hz, to much higher frequencies, 500,000 to 3,000,000 Hz

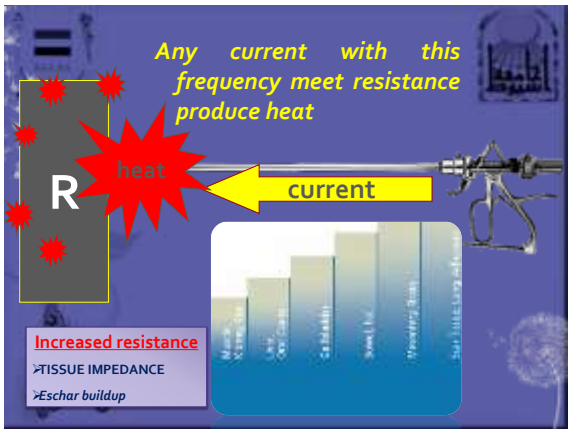
Monopolar Electrosurgery

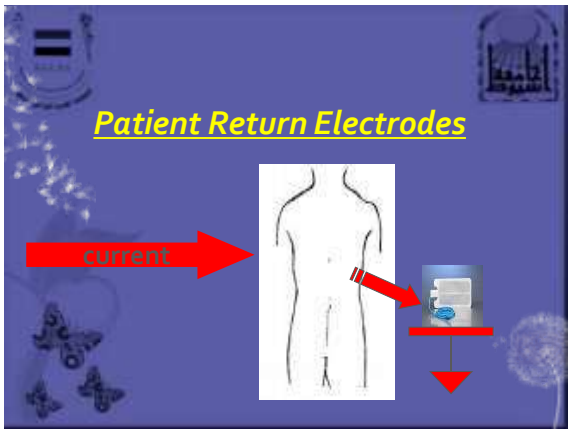


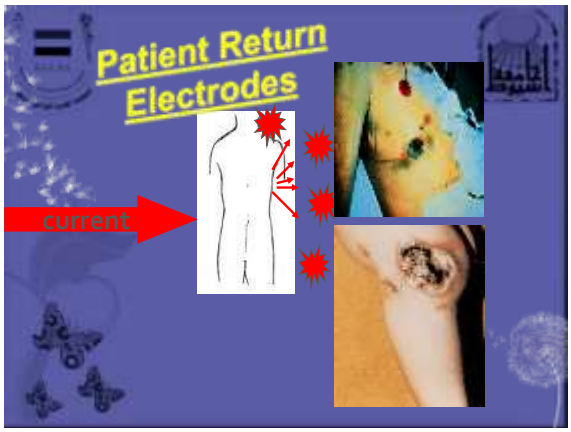
Bipolar Electrosurgery

Current path is confined to tissue grasped between forceps blades.



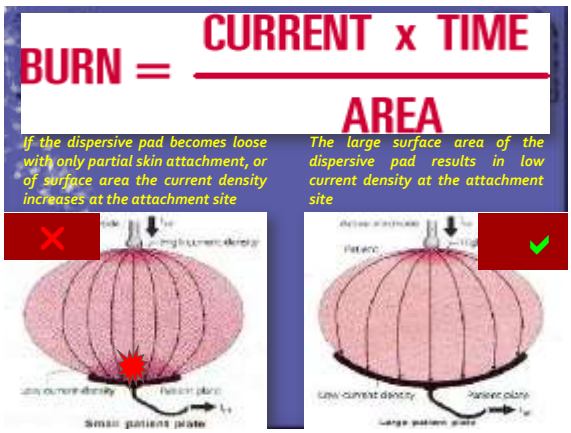


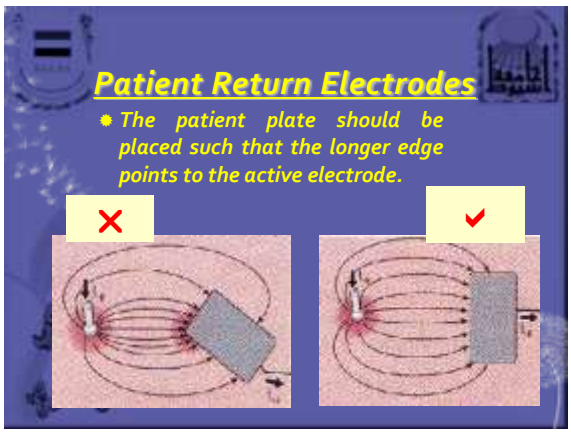




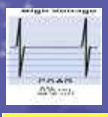
Patient Return Electrodes

- It should be applied to a wide area of electrically more conductive tissues like muscles.
- Don't use metal plates
- Use Large Silicon rubber plates

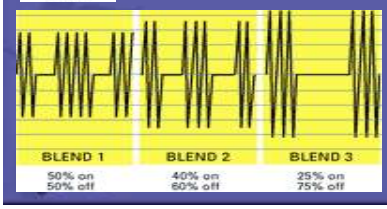




Constant waveform, is able to vaporize or cut tissue.



Interrupted waveform will produce less heat. and coagulation.



Blend 1 cut > coagul.

Blend 3 coagul. > cut

Complications

Three factors lead to stray energy burns

- direct coupling
- capacitive coupling
- insulation failure

direct coupling

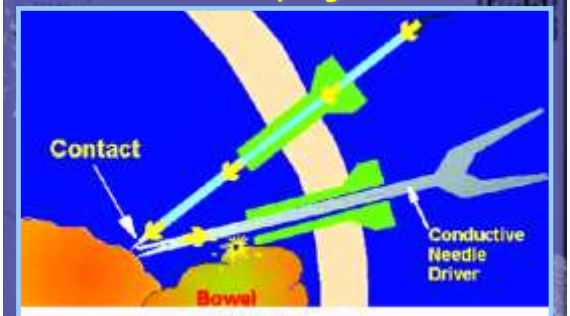


Fig. 4-7b

capacitive coupling

A capacitor creates an electrostatic field between the two conductors

The higher the peak voltage, the greater the chance for capacitive discharge

- *The low voltage "cut" mode exhibits less capacitive coupling than coagulation does.*
- *Surgeons must recognize that open circuit activation (electrode not touching tissue) dramatically increases voltage and the possibility of capacitive coupling .*
- *It is desirable to use as low voltage as possible and to limit noncontact activation of the generator.*

insulation failure

The smaller the defect, the higher the current density transferred

Insulation defects can range from normal wear and tear, to stress placed on the electrode from high voltages.

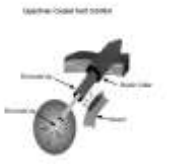
How to avoid

- When possible, place the long edge of the electrode closest to the surgical site and on the same side of the body as the incision in a sided procedure .
- Choose a well vascularized muscle mass .
- Avoid areas of vascular insufficiency, irregular body contours, bony prominences.
- Remove excessive hair.
- Check equipment before each use
- Patient skin is not in contact with metal or, if so, these areas are Insulated .

- Solutions are not stored on top of power unit .
- Power cord, dispersive pad cord, and cautery pencil cord are carefully placed to avoid possibility of being tripped .
- It is recommended that Cords not be wrapped around metal instruments Cords not be bundled together
- Foot pedal is dry .

- Flammable substances are used with care when power unit is in operation.
- Power unit is operated at lowest possible setting.
- Inspect insulation carefully.
- Use a low voltage waveform (cut).
- Use brief intermittent activation vs. prolonged activation .
- Do not activate in open circuit .
- Do not activate in close proximity or direct contact with another instrument .
- Use bipolar electrosurgery when appropriate.
- Activate the electrode when touching tissue.

- Select an all metal cannula system as the safest choice. Do not use hybrid cannula systems that mix metal with plastic .
- Clean the active tip routinely during surgery to prevent eschar buildup, which can cause tissue to stick and set up resistance to current flow.
- Visually inspect instruments throughout each procedure.



Utilize available technology, such as a tissue response generator to reduce capacitive coupling or an active electrode monitoring system.

Bipolar surgery

- Terminate current at the end of vapor phase
- Apply current in pulsatile fashion
- Alternate between desiccation and incision

Perioperative Management of Patients with Cardiac Rhythm Management Devices

- Assure that the electrosurgical receiving plate is positioned so that the current pathway does not pass through or near the cardiac rhythm management devices (CRMD system)
- avoid proximity of the cautery's electrical field to the pulse generator or leads .
- use short, intermittent, and irregular bursts at the lowest feasible energy levels .
- reconsider the use of a bipolar electrocautery system or ultrasonic (harmonic) scalpel in place of a monopolar electrocautery system, if possible.

Ultrasonic or harmonic scalpel (Ultracision,Harmonic, Sonic shear, sonic blade)

The Piezoelectric harmonic scalpel is a tool that simultaneously excises and coagulates tissue with high-frequency ultrasound. A frequency of 25 kHz results in dissection and cavitations; at >55 kHz thermal effects and coagulation take place. The harmonic scalpel is known to cause less collateral damage, avoids carbonization of the tissue and reduces local thermal damage. It has been used widely in laparoscopy for tissue dissection and control of local blood vessels. The harmonic scalpel is very helpful in achieving adequate haemostasis for retroperitoneal dissection. However, its use is limited to vessels up to 5 mm.

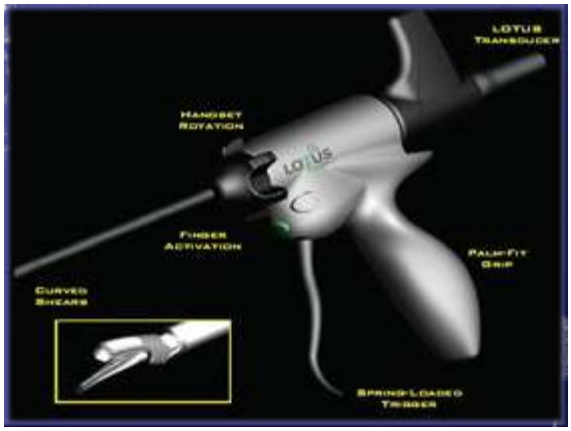
Haemostasis of larger vessels was not obtained, even when the harmonic scalpel was used at maximal coagulation power. They concluded that complete haemostasis of larger vessels (>5mm) cannot be achieved securely . The same problem may occur at the Santorini plexus or vascular pedicles. A promising development is the introduction of a new harmonic generator (Harmonic ACETM, Ethicon, USA). Owing to a higher velocity of transaction, the device is more rapid in tissue dissection, and vessels up to 5 mm can be sealed with decreased smoke formation or less lateral thermal damage to surrounding tissue, hence authors tried to perform some laparoscopic approaches with such device alone.

ULTRASONIC SCALPEL

Tissue welding, denaturing of proteins, no char, no plume, no electrical current through patient, no grounding, slower, but generally safer, surgical procedures, types of tips, hand pieces, 55,500 cycles/sec

The Ethicon cutting edge harmonic scalpel

The harmonic scalpel functions with a hand piece that oscillates at 55,000 Hz. When the vibrating blade couples with the protein in vessel walls, the protein is denatured forming a coagulum that seals vessels up to 5mm in diameter. The amount of heat generated in this process is less than produced by an electrocautery unit or even a CO_2 laser with minimal lateral thermal damage, and therefore minimal charring and tissue desiccation. This coagulation will allow for ligature or staple free surgeries such as a splenectomy. The accuracy in tissue dissection and excellent hemostasis should aid greatly with difficult soft tissue cases such as vascular adrenal or thyroid tumors as well as laparoscopic procedures. The addition of this new technology helps the operator continue providing the best care for patients.



2 A CLINICAL EVALUATION OF THE LOTUS™ ULTRASONIC SHEARS IN GYNAECOLOGICAL SURGERY
ARMADI D, FRAPPELL J, DRIOUZKO A, SIBANDA T, (2005) GYNAECOL SURG

THIS STUDY HAS COMPARED THE DIVISION TIME AND DEGREE OF THERMAL DAMAGE CAUSED IN THE IMMEDIATE VICINITY OF DISSECTION OF LARGE LIGAMENTS DURING ABDOMINAL HYSTERECTOMY AND BILATERAL SALPINGO-OOPHORECTOMY.

IN A TEN PATIENT STUDY THE ROUND AND INFUNDIBULOPELVIC LIGAMENTS ON ONE SIDE WERE DIVIDED USING LOTUS™ AND THOSE ON THE OTHER SIDE WERE DIVIDED USING POWER BLADE™ CUTTING BIPOLAR FORCEPS. TWO HUNDRED HISTOLOGICAL SAMPLES WERE PREPARED FROM THE EXCISED SAMPLES BY THE BLINDED HISTOPATHOLOGIST AND USING A PROTOCOL DEVISED BY THE TEAM, SEVERITY OF CELL DAMAGE AND SPATIAL EXTENT FROM THE POINT OF ENERGY APPLICATION WERE QUANTIFIED.

IT WAS FOUND THAT LOTUS™ WAS AS FAST AT CUTTING THE ROUND LIGAMENT AS THE POWER BLADE ™(MEAN TIME 0.96.1 AND FASTER AT CUTTING THE INFUNDIBULOPELVIC LIGAMENT (206. VERSUS 27.5S). (P=0.1688)

THE DEGREE OF THERMAL DAMAGE CAUSED BY LOTUS™ WAS LESS THAN THAT CAUSED BY THE POWER BLADE™ AT 2MM AND 5MM FROM THE APPLICATION SITE. NO THERMAL DAMAGE WAS SEEN 10MM FROM THE APPLICATION SITE FOR BOTH DEVICES.

BOTH INSTRUMENTS WERE EQUALLY EFFECTIVE IN SECURING HAEMOSTASIS IN ALL THE PEDICLES.

DUE TO THE SMALL SAMPLE SIZE THE RESULTS WERE NOT STATISTICALLY SIGNIFICANT.

3 COMPARISON OF HEAT DISSEMINATION FROM LONGITUDINAL AND TORSIONAL MODE ULTRASONIC SHEARS USING INFRARED THERMAL IMAGING AND THERMOCOUPLES
S.S CHING, PROF M.J. MCMAHON, ACADEMIC UNIT OF SURGERY, THE GENERAL INFIRMARY AT LEEDS, YORKSHIRE, UK

THIS STUDY COMPARED BOTH WAVEGUIDE BLADE AND TISSUE TEMPERATURES GENERATED BY LOTUS AND HARMONIC SCALPEL SHEARS IN VITRO.

USING A DIGITAL INFRARED CAMERA, THERMOGRAPHIC STILL IMAGES AND VIDEO WERE RECORDED AS BOTH DEVICES CUT INTO BOVINE MUSCLE TISSUE. IN ADDITION, 0.8MM THERMOCOUPLE NEEDLES WERE POSITIONED AT DEFINED DISTANCES FROM THE BLADE TO MEASURE THERMAL SPREAD DURING AND AFTER CUTTING.

AT A MEAN DISTANCE OF 3.70MM (P=0.843) FROM THE HARMONIC SCALPEL BLADE THE TEMPERATURE OF THE TISSUE ROSE BY 8.27°C (P=0.150). AT A MEAN DISTANCE OF 3.75MM (P=0.843) FROM THE LOTUS BLADE THE TEMPERATURE ROSE BY 10.17°C (P=0.150). THE MEDIAN SURFACE TEMPERATURE AT THE EDGE CUT BY THE HARMONIC SCALPEL WAS 78°C AND BY LOTUS WAS 69°C. THIS DIFFERENCE WAS ATTRIBUTED TO THE GENERATION OF SURFACE FRICTION BY THE LONGITUDINAL DEVICE.

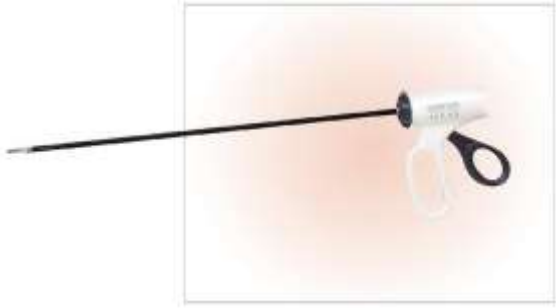
4 RANDOMISED CLINICAL TRIAL OF LONGITUDINAL VERSUS TORSIONAL MODE ULTRASOUND IN LAPAROSCOPIC CHOLECYSTECTOMY
S.S CHING, PROF M.J. MCMAHON, LIMIT, YORKSHIRE, UK

THIS STUDY HAS COMPARED TWO ASPECTS OF LAPAROSCOPIC CHOLECYSTECTOMY PERFORMED USING LOTUS OR THE HARMONIC SCALPEL SUPPLIED BY ETHICON ENDOSURGERY.
A TWENTY PATIENT RANDOMISED STUDY COMPARED THE FOLLOWING ASPECTS OF SURGERY WHEN PERFORMED USING THE TWO DEVICES:

- BLOOD LOSS
- SURGERY TIME

IT WAS FOUND THAT USING LOTUS RESULTED IN A RANGE OF BLOOD LOSS FROM 0 - 175ML WITH A MEDIAN VALUE OF 7.1ML. THIS IS TO BE COMPARED WITH A RANGE OF BLOOD LOSS OF 0 - 925ML WHEN THE HARMONIC SCALPEL IS USED WITH A MEDIAN VALUE OF 21.5ML. IN ADDITION, LOTUS APPEARED TO REDUCE THE EXCISION TIME FROM 7 TO 43 (MEDIAN 19.5 MINUTES) FOR THE HARMONIC SCALPEL, TO 5 TO 41 MINUTES (MEDIAN 11 MINUTES) WITH LOTUS.

DUE LARGELY TO THE SMALL SAMPLE SIZE P>0.05 FOR THE TWO SETS OF DATA RESPECTIVELY. TO REDUCE THE P VALUE TO THE ORDER 0.05 A LARGER FOLLOW UP STUDY HAS BEEN PROPOSED, APPROVED BY ETHICS AND RESEARCH COMMITTEES AND IS ALREADY UNDERWAY.



The HARMONIC SCALPEL® Shear

The HARMONIC SCALPEL Shear uses ultrasonic technology, the unique energy form that allows both precise cutting and controlled coagulation with minimal lateral thermal tissue damage.

It offers safer dissection near vital structures compared to electrosurgery or lasers. Fewer instrument changes are needed, less tissue charring and dessication occur, and visibility in the surgical field is improved. Introduced commercially in 1993, the HARMONIC SCALPEL Shear and the LAPAROSONIC® Coagulating Shears (LCS) have now been used by thousands of surgeons worldwide in laparoscopic and open surgical procedures.

INDICATIONS

The HARMONIC SCALPEL Instruments are indicated for soft tissue incisions when bleeding control and minimal thermal injury are desired. The instruments can be used as an adjunct to or substitute for electro cautery, lasers, and steel scalpels.

CONTRAINDICATIONS

- The instruments are not indicated for incising bone.
- The instruments are not indicated for contraceptive tubal occlusion.

WARNINGS AND PRECAUTIONS

Slide 57: Anatomy of a Harmonic Scalpel: LCS – Ligating Cutting Shears

So if you were to look at a harmonic scalpel, what you really see is an ultrasound with a tissue-handling part and an ultrasound blade, which is oscillating at a set frequency. It can be changed according to how far the blade comes up per cycle. Those are called the power settings, the levels.

Ultrasonic Energy

Ultrasonic energy is mechanical energy and ultrasonic forces are used to cut and coagulate. And in somewhat of a similar fashion the context of how collagen works and how it's configured and how it is manufactured by the body is that if you agitate collagen enough you can deconfigure it by breaking up the hydrogen bonds. You can denature the protein. Then if you keep rubbing tissue, just as if I kept rubbing your back, it would start to get warm, the heat starts to form steam, and the steam wants to percolate through the tissue. As the tissue gets percolated with steam, what happens is it falls apart, which is called cutting. So, ultrasonic energy creates steam, which percolates through the parenchyma, breaks up the parenchyma, and tissue falls apart, called cutting.

Electrosurgical Collagen Welding

Finally, we have this whole phenomenon, which is very well described, which is collagen welding. It is a very interesting and intriguing thought. Here, if you take a certain amount of pressure over a certain amount of time with a low output of energy...

Vessel wall fusion can be achieved using RF energy to denature collagen and elastin to reform into a permanent seal

... you can actually do something very interesting. You can take the collagen and elastin in blood vessels and you can use the radio frequency energy of your electricity to heat and seal with a collagen glue and do collagen welding, forming an incredibly powerful vascular glue.

Ligasure Vessel Sealing System

That is the basis for Ligasure. Again, low-voltage, high current, impedance feedback, but here of course we have another element, which is the delivery of an optimal amount of pressure with the moderation of energy output to give you collagen welding, and to give you a glue that basically closes the front of the vessel to the back of the vessel with a variety of instruments.

CUSA

- Cavitronic Ultrasonic Suction Aspirator
- A great difference between CUSA and Harmonic Scalpel
- Surgical applications of CUSA

Through a peep hole . . . .

Developments which have stood the test of time (without prospective randomized studies).

. . . AND . .

Single instrument ,double trocars, cholecystectomy using harmonic scalpel

By
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LAPAROSCOPIC CHOLECYSTECTOMY

MASTECTOMY

HEMORRHOIDECTOMY

SINGLE WORKING INSTRUMENT, DOUBLE TROCARS, CLIP LESS CHOLECYSTECTOMY USING HARMONIC SCALPEL. A FEASIBLE, SAFE, AND LESS INVASIVE TECHNIQUE

Laparoscopic cholecystectomy is commonly performed operation for patients diagnosed with gall stones. Usually the procedure involves electro surgery and sealing of the gall bladder duct and arteries with titanium clips. Dissection with concomitant hemostasis can be performed with the use of ultrasonic instruments as harmonic scalpel that can radically simplify the whole operation and offer good hemostasis.

(Nazih, 2008 & Bessa, 2008)

The ultrasonically activated scalpel has proven to be an effective, efficient, and safe instrument for dissection and hemostasis. It works on the tissue's cutting and coagulating very effectively with the replacement the high frequency current. The primary use of the Harmonic scalpel in laparoscopic cholecystectomy has been for the division of the cystic artery and liver bed dissection then used to seal the cystic duct in clip-less cholecystectomy procedure.

(Foschi et al, 2009)

The resulting decrease in temperature, smoke, and lateral tissue damage placed the Harmonic scalpel in contrast to the effects seen with the more traditional electrocautery. In addition, the elimination of inadvertent, sometimes unrecognized, electrical arcing injuries with their potentially hazardous sequelae supported the role of the Harmonic scalpel as a potentially safer instrument for tissue dissection, moreover, it shortens the operative time and decreased the rate of accidental bile spillage.

(Maciej et al , 2007)

The bursting pressure of the cystic duct sealed by ultrasonic energy was 168±47 mm Hg, well above the maximal pressure of the common bile duct. At scanning electron microscopy, the end of the cystic duct was closed by an amorphous, bundled, dense substance. The section proximal to the end showed destruction of the epithelial layer with dense amorphous bridges connecting the opposite sites of the wall. When the lumen was observed, it was filled with bile micro aggregates. (Foschi et al, 2009)

At transmission electron microscopy, 2 different findings were evident: (1) coagulative necrosis in the sectioned area and (2) a combination of coagulative necrosis and collagen denaturation in the more distal sections. The connective tissue was characterized by attenuation of collagen birefringence and swelling of fibers and bundles due to shrinkage of collagen.

Conclusions: Ultrasonic energy can be applied to suitable tissues to obtain sealing of the walls with good biomechanical effects. (Foschi et al, 2009)

WHY A SINGLE WORKING INSTRUMENT ?

Because a single working instrument means avoidance of repeated instrument changes during the operation, as selecting different instruments breaks the natural flow of the operation and may distract the surgeon, hence it can affects the surgical technique and operation time

(Marshall Nicholas, 2007)

Downsizing the ports & incisions

after laparoscopic cholecystectomy improves postoperative pain control, with rapid return to activity and work, better patient satisfaction, and better cosmetic results. So new techniques for laparoscopic cholecystectomy were designed to reduce the number of trocars or the use of very thin instruments with the goal of further minimizing surgical invasiveness.

(Miguel et al, 2007)

some authors use one 1-mm Kirschner wire, introduced at the sub costal line and bent with a special designed device to hook the gallbladder and pull it up.

(Miguel et al, 2008)

Others used 2-mm grasper forceps inserted directly without a trocar below the costal margin, then the fundus of the gallbladder is ligated and lifted up with a folded o silk string and a 16-gauge vessel cannula.

(Mori et al, 2002)

These feasible, safe, minimal invasiveness techniques results in a much smaller wound with less pain than conventional laparoscopic cholecystectomy, and considered as an alternative way to deal with gallstone disease, especially for younger women, who tend to be more concerned about cosmetic outcome.

(SEN-CHANG YU, 1999)

Open surgery

Laparoscopy

NOTES

This study was undertaken to demonstrate the efficiency, and safety of the Harmonic scalpel as the sole instrument in closure/division of the cystic duct and artery, and bladder dissection to achieve complete hemo-biliary stasis during the performance of laparoscopic cholecystectomy, with the use of two trocars technique, compared with the conventional clip/cautery, three trocars laparoscopic technique

Group►	Group I		Group II		Total	
Age▼	Males	Females	Males	Females	Males	Females
<20 Years	2	3	2	2	4	5
20-30	8	17	4	8	12	25
30-40	7	20	6	9	13	29
40-50	6	7	14	18	20	25
50-60	4	5	5	9	9	14
>60 Years	-	1	2	1	2	2
Total	27	53	33	47	60	100
Percentage	16.9	33.1	20.6	29.4	37.5	62.5

Table (1): showed age and sex incidence

Groups ▶ and duration ▼	Group I	Group II	P. Value
Range (minutes)	9-30	35-55	0.0001 Highly significant
Mean (minutes ± SD)	20 (16.8±6.8)	45 (44.01±6.47)	

Table (2) showed duration of the operation.

The complication	Group I		Group II		P Value
	No.	%	No.	%	
Bile spillage	8	10	11	13	0.46 Not significant
Biliary injury	-	-	-	-	-
Bleeding	-	-	1	1.3	-
Difficult to proceed	1	1.3	1	1.3	-
Conversion to open	-	-	-	-	-

Table (3) showed intra operative complications.

Groups & Item	Group I		Group II	
	No.	%	No.	%
Biliary soaking	-	-	1	1.3
Biliary injury	-	-	-	-
Abdominal collection	-	-	-	-
Post-operative pain	mild		Moderate	
Analgesics doses	Single		Double	
Post-operative Ileus	-	-	-	-

Table (4) showed post operative complications.

The Item	Group I	Group II	P. Value
Range of hospital stay period	1	1-2	0.001 Significant
Mean duration of hospital stay (± SD)	1 (1.00 ± 0.00)	1.5 (1.53 ± 0.51)	

Table (5): showed periods of hospital stay (* means Insignificant)

Conclusion

The Harmonic scalpel is a safe, efficient, and practical instrument to use during laparoscopic cholecystectomy especially if used as a sole working instrument, with complete hemo biliary stasis. Its application shortens the operative time and decreases accidental bile spillage; hence decreases postoperative complications, with shorter hospitalization period.

Downsizing the number or size of laparoscopy trocars improved the results of minimal invasiveness with better recovery, less pain, improved cosmesis, and better satisfaction.

Thank you