Laparoscopic Tissue Approximation Techniques

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Knots are used since the time of primitive man for trapping animals and making weapons. Today's laparoscopic knots are basically a modification of knots used by Seamen, Fishermen, Weavers or Hangmen. In much of the literature on laparoscopic surgery, the learning curve for performing the technique is described as steep. In fact, laparoscopy is more than a new technique; it is a completely different way of operating as far as tissue approximation is concerned. The visualization is different, the instruments are different, and the tactile aspects are very different. Laparoscopic suturing and knotting is a skill that requires a great deal of practice: "As a young surgeon in training, you sit up all night, night after night, tying knots over and over and over again until you become perfect".

There are many ways of laparoscopic tissue approximation but most commonly used one are:

- Laparoscopic extracorporeal and intracorporeal knots
- Surgical glues which act as a tissue adhesive
- Laparoscopic clips
- Laparoscopic staplers
- Laser welding.

LAPAROSCOPIC SUTURING AND KNOTTING

It is important to remember that knot is either exactly right or is hopelessly wrong, and never nearly right.

There are three steps of knot tying:

- Configuration (Tying)
- Shaping (Drawing)
- Securing (Locking or snuggling).

Choice of Suture Material

Ideal Suture Characteristics

The choice of suture material influences wound healing. Ideal suture characteristics include:

- Good knot security
- Adequate tensile strength
- Flexibility and ease of handling
- Inertness and non-allergenic nature

- Resistance to infection
- Smooth passage through tissue
- Absorbability, when desirable.

Surgeons should choose sutures that they are comfortable with, and that are suited to the intended application. This choice should be based on the duration of tensile strength. For internal sutures, least number of knots should be used, to ensure knot security and avoid an excessive knot burden and consequent foreign body reaction.

Type of Suture

Sutures traditionally have been classified into natural (i.e. naturally occurring), and synthetic (man made). The use of natural sutures is declining, for a number of reasons like tissue reaction, infection, weak knots. Examples of natural sutures include catgut and silk. Suture material is also classified into absorbable and non-absorbable.

Absorbable Sutures

The natural absorbable (catgut) tend to have unpredictable rates of absorption and tissue reaction. For the most part, these sutures have short half-lives, so they are not good for wound closure where strength is desirable. Their use is being discontinued.

The synthetic absorbable are broken down by hydrolyzation. They generally have a longer half-life, less tissue reaction, and a more consistent breakdown rate. The synthetic absorbable, polyglycolic acid (Dexon®) or polyglactin 910 (Vicryl®), have decreased tissue reaction compared to the natural absorbable. Knot security is fair and can be used for extracorporeal knotting.

Polyglactin 910 (Vicryl) keeps 75 percent of its tensile strength for about 2 weeks and 50 percent by 3 weeks. The coated sutures decrease the drag through tissue, so it is easier to use, but there are variable rates of absorption. Polyglactin is good suture material for intracorporeal suturing.

Poliglecaprone 25 (Monocryl®) is a monofilament product that has easy passage through tissue, good handling, and is inert. It keeps tensile strength for only a week, but stays in the wound for almost 4 months. It is good for anastomosis, gynecologic work, and small vessel ligation and epithelial approximation. This material can be used for both extra and intracorporeal suturing.

The delayed absorbable monofilament sutures such as polydioxanone (PDS®) and polyglyconate (Maxon®), used for abdominal wound closure have good tensile strength and low tissue reaction, but the knots are not as strong. PDS is considered as ideal material for extracorporeal knotting by many surgeons and gynecologists.

Polydioxanone (PDS) is also good for contaminated fields because it has a low affinity for bacteria. It is good for general use, tissue approximation, biliary work, anastomosis, fascial closures, heart surgery, and orthopedics.

Panacryl® is a braided synthetic absorbable suture. It has good tensile strength, low tissue reaction, and fairly good knot security. It maintains 60 percent of its tensile strength at 6 months. It may be a good substitute for a non-absorbable suture because it has complete absorption in 2½ years. It is good for fascial closures, closing tissues under tension, and it might have a role in the compromised patient where you presume there is going to be inadequate or delayed wound healing.

Non-absorbable Sutures

The natural non-absorbables, cotton and silk, should be relegated to the past. Even though they have good knot security, and are easy to tie, they provoke a lot of tissue reaction. Synthetic non-absorbable sutures in common use include nylon, polyester and stainless steel. The role of this material in laparoscopic surgery is very limited and can be used if the other materials are not available.

Suture Size

The narrower the suture, the lower is its tensile strength. Narrower sutures cause less scarring. In addition, a narrower suture will harbor fewer bacteria.

Surgeons should use the smallest suture that they are comfortable with and that will give optimal security of wound closure, with minimal wound tension.

Usually, 2/0 or 3/0 is used in most of the minimal access surgical procedure, with the exception of the fallopian tube, where 6/0 may be preferred.

Knots

The knot is the most important part of the suture closure *in vivo*, the knot is the determining factor in suture strength in 95 percent of sutures tested. Complex knots have twice the security of simple knots.

However, increasing complexity of the knot simply leads to the suture strength being the weak link. The size of the knot is also important. If you use the same suture and increase from 3 to 5 throws, the foreign body volume is increased by 50 percent.

LAPAROSCOPIC NEEDLE

In general surgery, needles are either straight or curved. With increasing proficiency, curved needle can also be used but in laparoscopic surgery most intuitive needle is endoski needle. Endoski has advantage of both straight and curved needle (Fig. 8.1).

Fig. 8.1: Endoski needle

Endoski Needle

The distal end is tapered half circle and proximal shaft of the needle is straight. The shaft of the needle is 1.5 times the length of curved portion of endoski needle.

In our day to day practice we can convert half circled needle into endoski shaped by making proximal half of the needle straight.

Laparoscopic Suture Material

Although it is a personal preference and varies surgeon to surgeon but considering handicap of laparoscopic setting following is recommended.

- For extracorporeal suturing of small tubular structure like cystic duct and small blood vessels: dry chromic catgut.
- For extracorporeal suturing of thick tubular structure like appendix and large blood vessels: PDS.
- For intracorporeal continuous or interrupted suturing: Vicryl.

- For intracorporeal interrupted suturing in the repair of hernia, Fundoplication and rectopexy: Dacron (polyester) or silk.

Types of Laparoscopic Surgical Knots

- Extracorporeal (Tied outside the body and then slipped inside using a push rod)
  - Roeder's knot
  - Meltzer's knot
  - Tayside knot.
- Intracorporeal (tied with the help of needle holder within the body cavity)
  - Square knot
  - Surgeons knot
  - Tumble square knot
  - Dundee jamming knot
  - Aberdeen termination.

A long length of ligature is required (90 cm) for extracorporeal suturing. It must be long enough to have the knot pusher threaded on to it, to be passed into the abdomen, round the structure to be ligated and to be brought out again and still have sufficient length for the surgeon to tie his/her knot effectively. The type of extracorporeal knot chosen to complete the loop depends on the clinical situation and the material used.

ROEDER'S KNOT (FIGS 8.2A TO U)

FIG. 8.2A

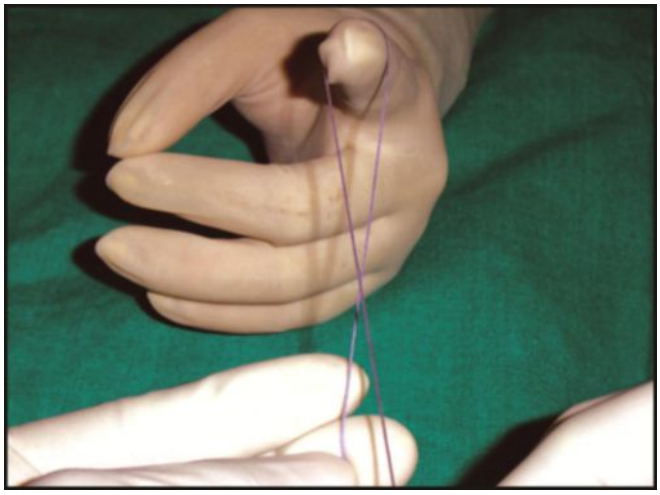


FIG. 8.2B

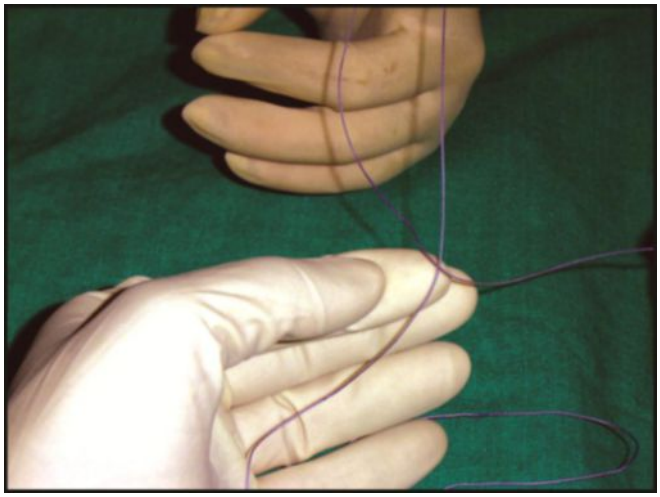


FIG. 8.2C

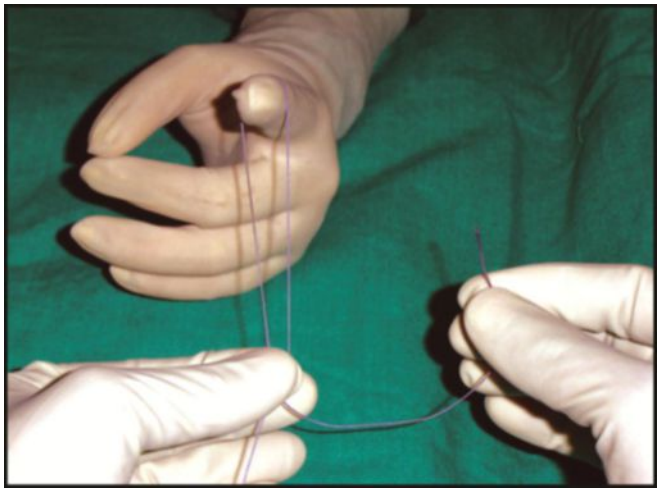


FIG. 8.2D

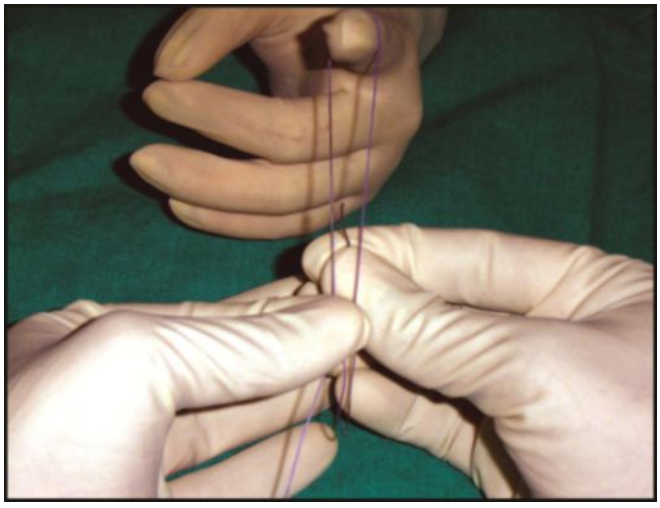


FIG. 8.2E

FIG. 8.2F

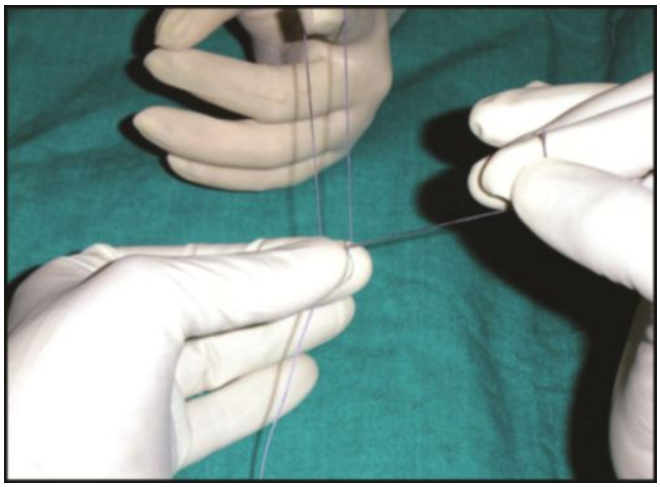


FIG. 8.2G

FIG. 8.2H

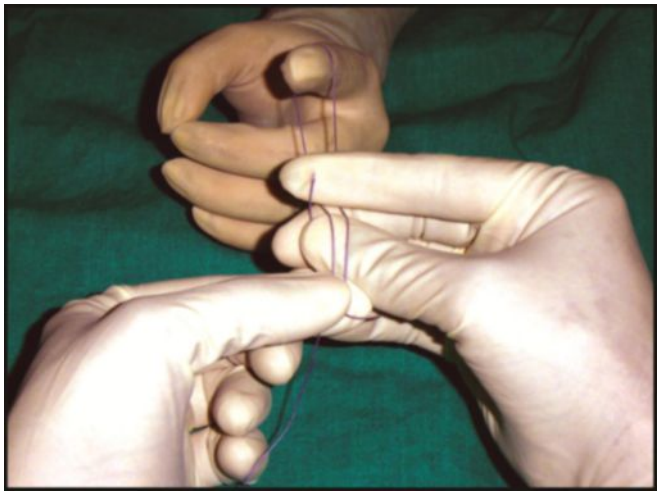
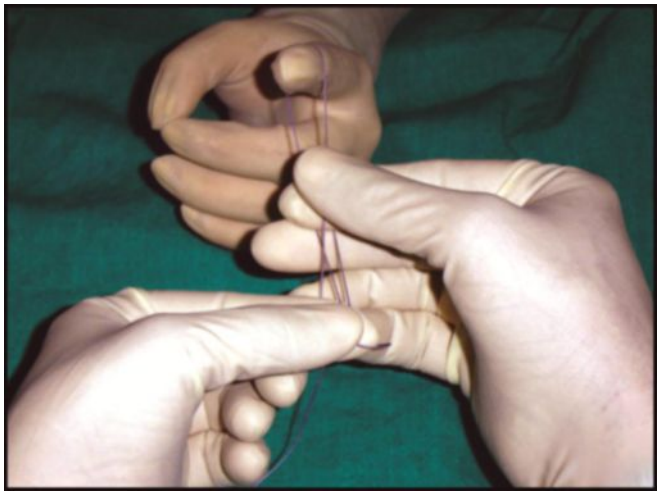


FIG. 8.2I



FIGS 8.2J

FIG. 8.2K

FIG. 8.2L

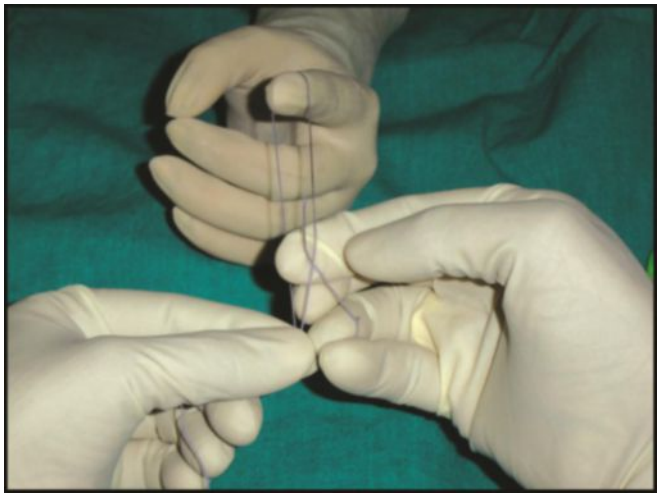


FIG. 8.2M

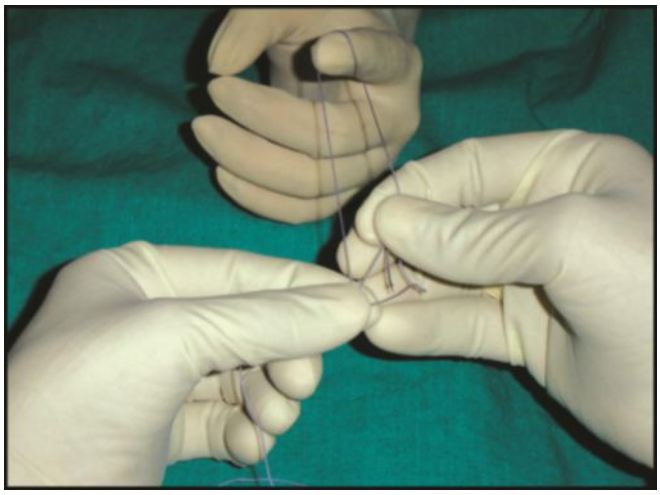


FIG. 8.2N

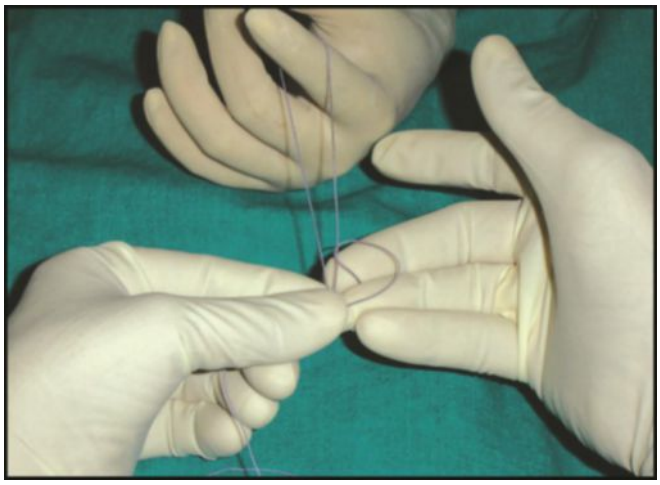


FIG. 8.2O

FIG. 8.2P

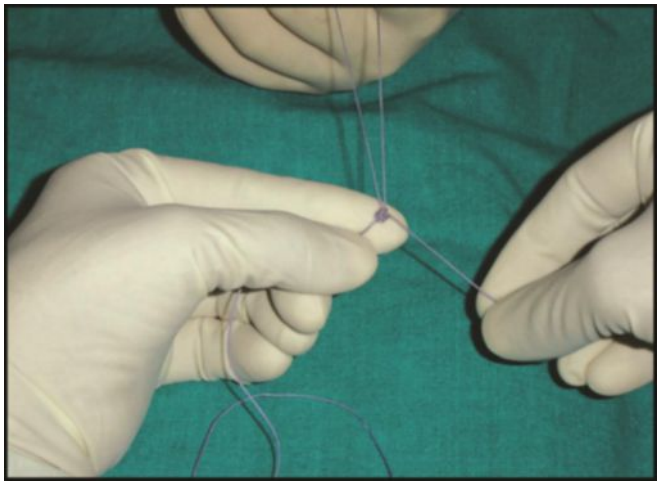


FIG. 8.2Q

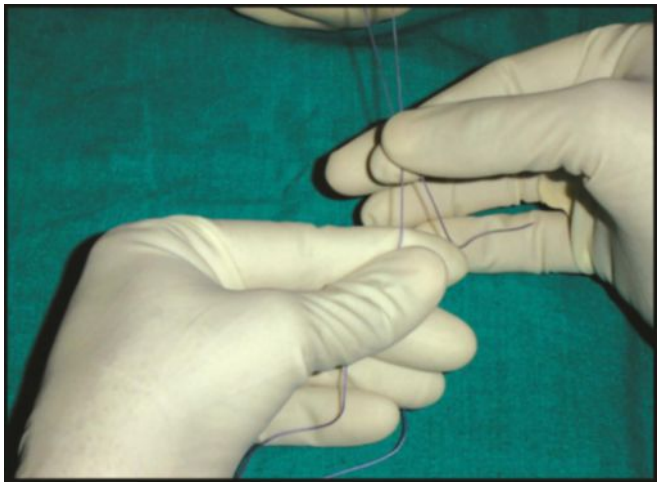


FIG. 8.2R

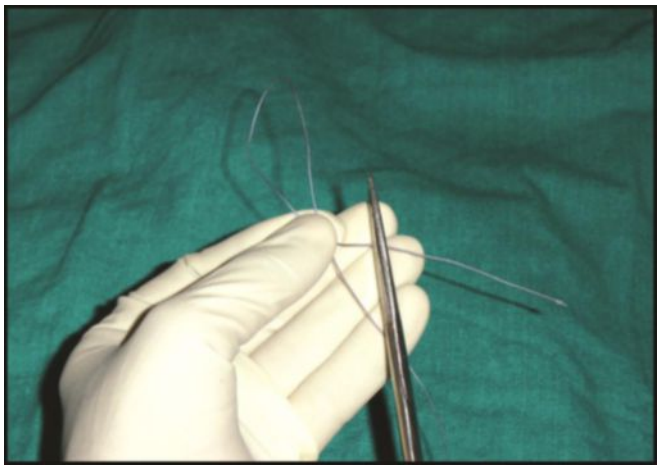


FIG. 8.2S

FIG. 8.2T

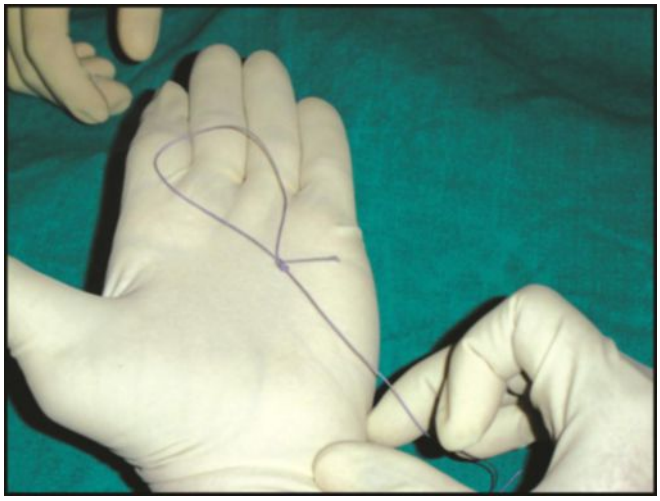


FIG. 8.2U

FIGS 8.2A TO U: VARIOUS STEPS OF ROE**DER'S KNOT**

Step 1: The index finger of the assistant may be used to make extracorporeal knot. The left hand should be used to hold the short limb and the right hand long limb of thread.

Step 2: The short limb of the thread is crossed over the long limb.

Step 3: The intersection point of thread should be pinched by left hand index finger and thumb. At the time of making intersection, surgeon should keep sufficient length of short limb, to make it comfortably. It is important to remember that left hand is used only to hold the intersection point while the right hand will make the necessary hitches and loops.

Step 4: The short limb is passed between the thread upward.

Step 5: The short limb should be pulled from up by right hand to make first hitch.

Step 6: The short limb should encircle the thread from below upward.

Step 7: With the index finger and thumb the tail end is held.

Step 8: The tail end of the thread is pulled to make first wind. Step 5 to 7 should be repeated two more times to make three winds.

Step 9: After making three winds, the tail end is again passed from below up between the threads.

Step 10: Once the tip of tail end projects up, it is pushed down by thumb inside the loop to make half knot.

Step 11: The tail end is pulled from below to tighten the half knot.

Step 12: Once the knot is configured properly, it should be checked by sliding over the long thread.

Step 13: The tail end of knot should be cut short approximately to 2 cm.

Properly configured reader's knots loop diameter should be approximately 4 cm. Large size loop is difficult to manipulate inside the abdominal cavity and very short loop is difficult to reach up to the base of the structure which is to be tied.

Roeder's knot can be remembered as 1:3:1

- One hitch
- Three winds
- One locking hitch.

The Meltzer Slip Knot

This modification of the Roeder knot was described in 1991 by Meltzer for use with PDS, and has now superseded the use of Roeder's knot. It has components:

- Two hitches
- Three winds
- Two-half locking hitches

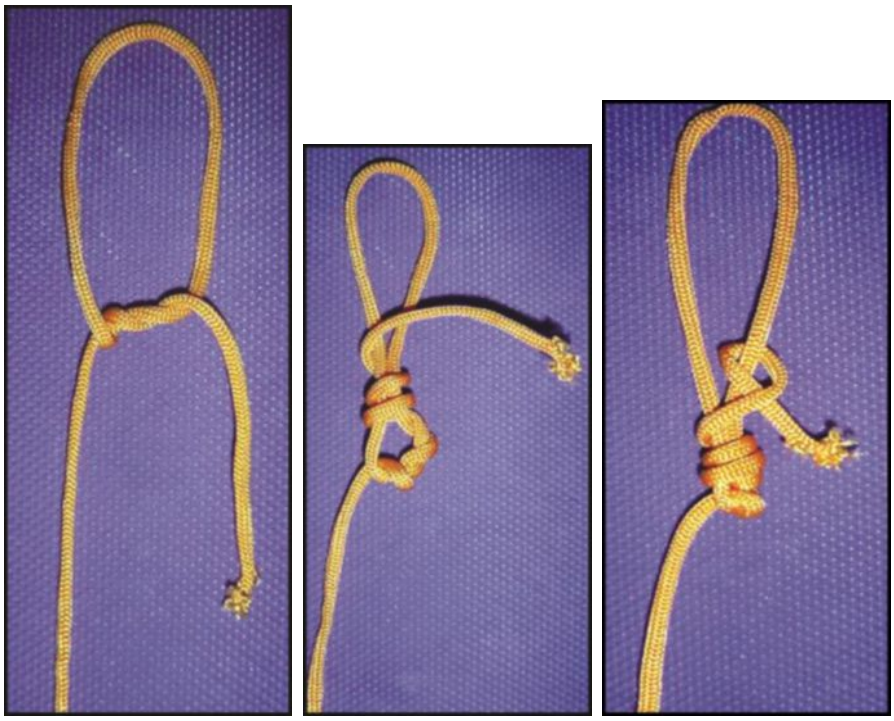
Meltzer knot can be remembered as 2:3:2

Tying a Meltzer knot

Step 1: Two-half knot is taken first (Fig. 8.3A)

Step 2: Three rounds are taken in front of the first double half knot over both the limb of loop (Fig. 8.3B).

Step 3: Stack the knot and trim the short end. Slide the knot into place with knot pusher under tension (Fig. 8.3C).



Figs 8.3A to C: Step of Meltzer slip knot

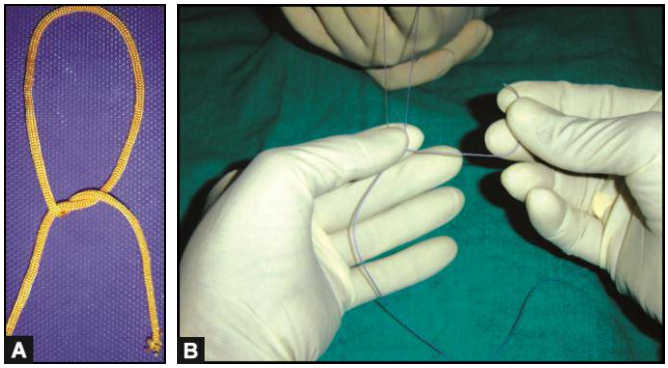
APPLICATIONS

The Meltzer knot is now used by most of the surgeons instead of the Roeder knot to tie the medial end of the cystic duct during cholecystectomy and to fix the cystic duct drainage cannula after trans-cystic clearance of ductal stones, as catgut is no longer available. PDS is the suture material of choice for Meltzer knot.

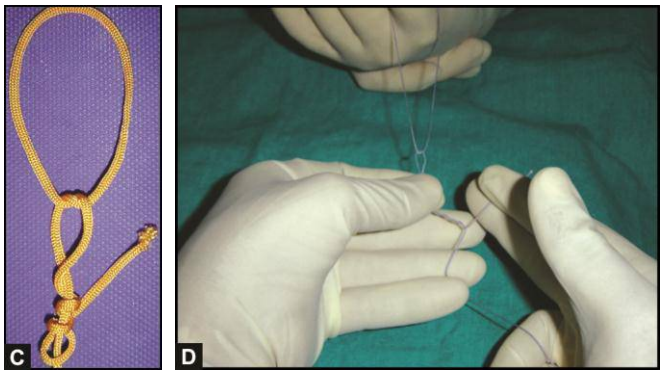
The Tayside Knot (Figs 8.4A to O)

The Tayside knot is safe for use with any braided material. It supplies a degree of resistance to reverse slippage equivalent to a surgeons knot.

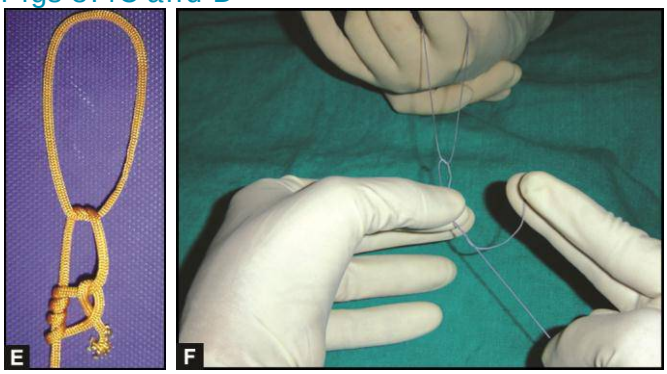
Step 1: A single hitch is taken first just as Roeder's knot.
Step 2: Four and a half rounds are taken approximately 1 cm below the first hitch over long limb of thread.
Step 3: A locking hitch is made by passing tail through the second and third loop.
Step 4: Finally the first hitch is brought closer to the locking hitch by spreading the first loop.
Step 5: The knot is stacked properly and the extra tail (if any) is cut. Once the knot is configured properly, it should be checked by sliding over the long thread.



Figs 8.4A and B



Figs 8.4C and D



Figs 8.4E and F

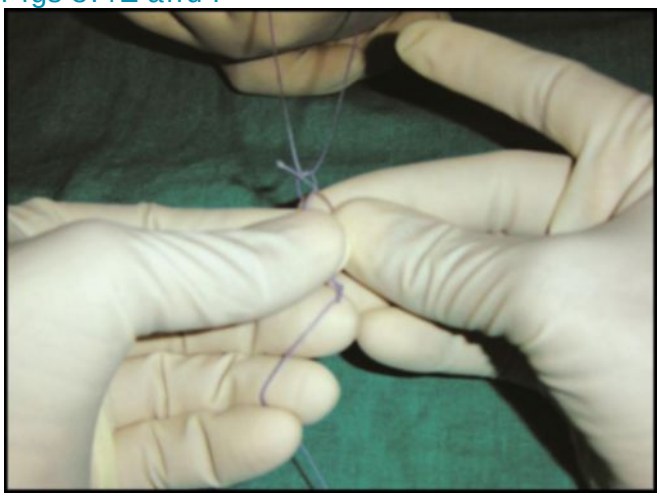


Fig. 8.4G

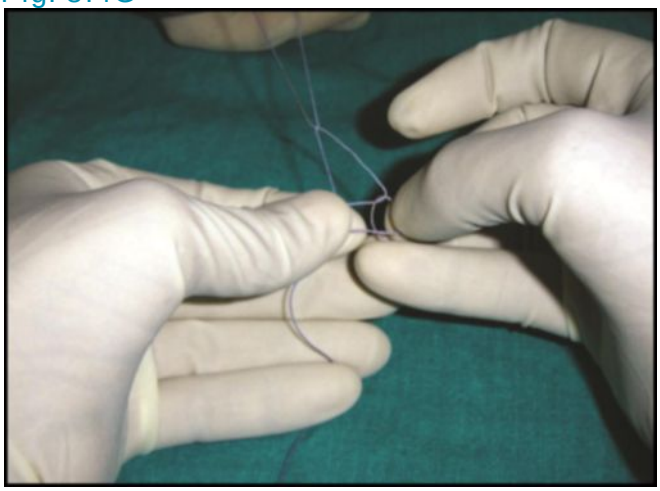


Fig. 8.4H

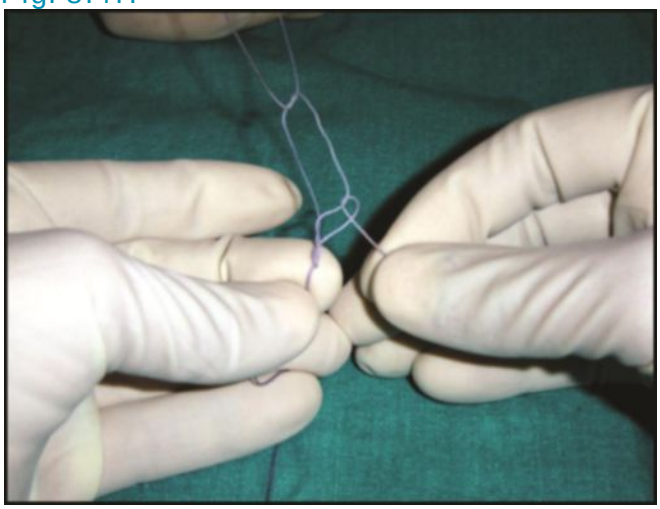


Fig. 8.4I

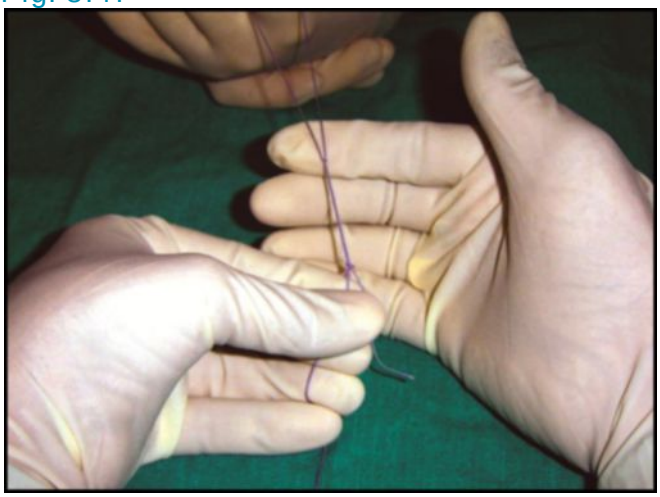


Fig. 8.4J

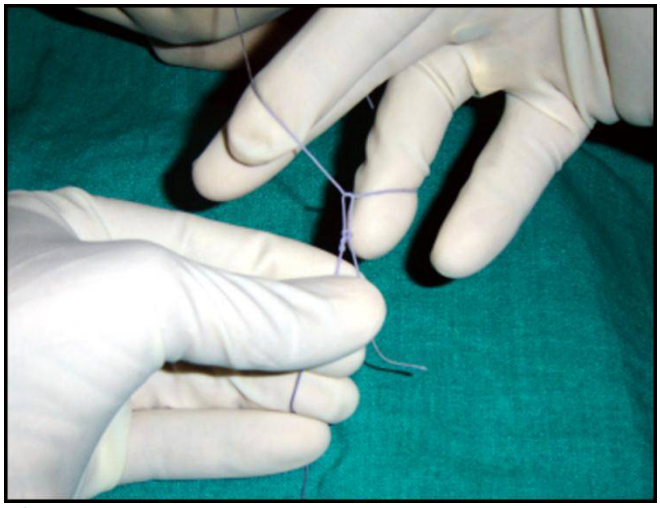


Fig. 8.4K

Fig. 8.4L

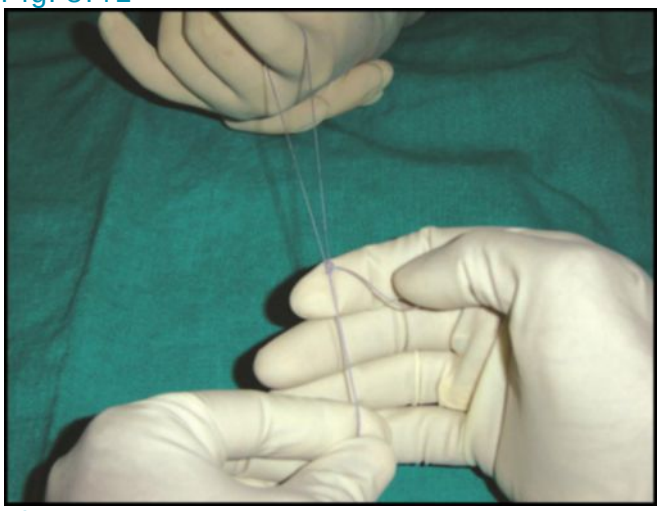


Fig. 8.4M

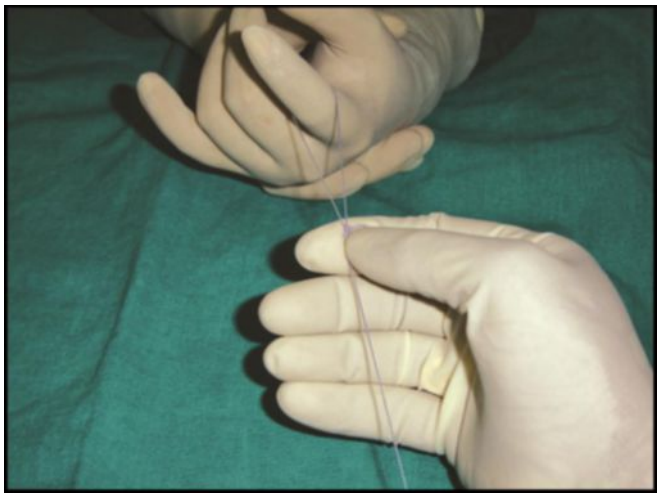


Fig. 8.4N

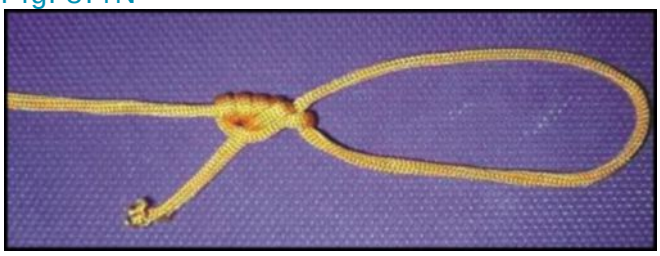


Fig. 8.4O

Figs 8.4A to O: Various step of Tayside knot

APPLICATIONS

The Tayside knot is suitable for use with all braided sutures (2/0 or stronger) as well as dacron. It is used with Dacron for ligation of vessels such as the azygous vein, splenic artery/vein or the inferior mesenteric artery/vein.

USING A PRE-TIED LOOP (FIG. 8.5)

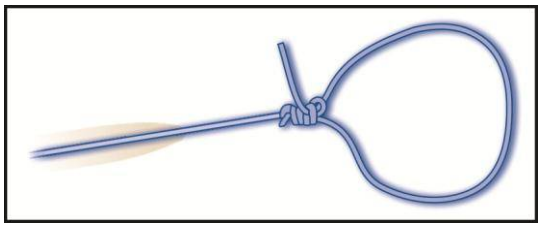


FIG. 8.5: **ROEDER'S LOOP**

- The loop is drawn up into the metal sleeve.
- The tube is then introduced through an abdominal port.
- Once inside the abdomen the loop is advanced using the push rod.
- A grasping forceps is placed through the loop and used to grasp the tissue to be ligated.
- The loop is delivered over the tissue and the knot and push rod positioned at the base of the tissue.

- The loop is then tightened around the tissue by tensioning the long end and applying pressure to the knot via the push rod causing it to slide.
- The knot is locked firmly in place.
- The graspers are removed and replaced by suture scissors to divide the long end prior to removal.

Pre-tied loops are available commercially. They are packaged with the following items, assembled ready for use.

- A push rod
- A pre tied loop
- A metal or silicon introducer tube.

The pre-tied loop has one long tail of suture material, which is threaded through the plastic push rod and encapsulated by the end. The region at the end of the push rod is designed to be broken so the thread may be pulled through the remainder of the rod. The push rod is passed through the metal introducer tube.

Clinical Uses

Preformed loops are used to ligate tissue, e.g. the base of the appendix, lung bullae and a hole in the gall- bladder during cholecystectomy. If multiple loops are required, the push rod and introducer can be reloaded with a length of ligature and additional loops fashioned by a surgeon with knowledge of external slip knots.

A pre-formed loop can also be used to secure a divided vessel after it has been isolated by a grasper. A slight modification of this technique allows it to be used to secure smaller identified vessels. One end is clipped and the other controlled by a grasper, which has already been passed through a loop. The vessel is divided and the loop slide into place and tightened before the grasper releases the vessel.

Endoloops are also useful for sealing a perforated organ if this is to be removed, e.g. perforation of the gallbladder during laparoscopic cholecystectomy where closure is necessary to prevent escape of gallstones into the peritoneal cavity.

On no account must endoloops be used to close a perforation in any organ that is not going to be resected and removed, as the tissue included in the closed endoloop will slough off a few days later, because of ischemia, resulting in peritonitis.

EXTRACORPOREAL KNOT FOR CONTINUOUS STRUCTURE

- A push rod is threaded onto a length of ligature material approximately 1.5 m long.
- A knot is tied at the end of the thread as it emerges from the straight end of the rod.
- The end of the ligature emerging from the tapered end is grasped by atraumatic endoscopic grasper.
- The grasper and catgut are then passed into an introducer tube.
- The introducer tube is then passed through an 11 mm cannula.
- The grasper and ligature are extended into the cavity and passed to one side and behind the structure to be ligated.
- A second grasper is introduced through a second port to grasp the ligature from the other side of the structure.
- The first grasper releases the ligature and the takes it back from the second in front of the structure.
- The first grasper and ligature are withdrawn from the abdomen through the introducer tube while the second is used to protect the structure from the suture.
- An external slip knot is tied externally. The knot tied is determined by the size of vessel to be controlled and the material in use.

- The knot is pushed into the abdomen by the push rod and positioned prior to tightening.
- The rod is withdrawn a little and scissors introduced to cut the thread leaving a reasonably long end.

Clipping

Titanium clip is most widely used tissue approximation technique used by general laparoscopic surgeon.

- Choose the correct size of clip for the structure.
- Double clip should be applied over important structures (Fig. 8.6).
- Always confirm the dumbbell effect after clipping.
- Dumbbell effect after clipping confirms the tension on tissue (Fig. 8.7).
- Do not clip fatty pedicles.
- Check positioning of jaws, the tips and content before clipping.
- Beware of cross clipping (Fig. 8.8).

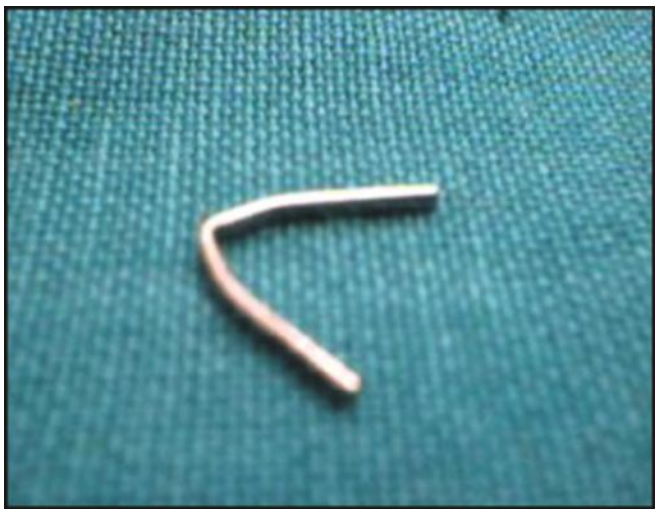


FIG. 8.6: TITANIUM CLIP

FIG. 8.7: DUMBBELL FORMATION

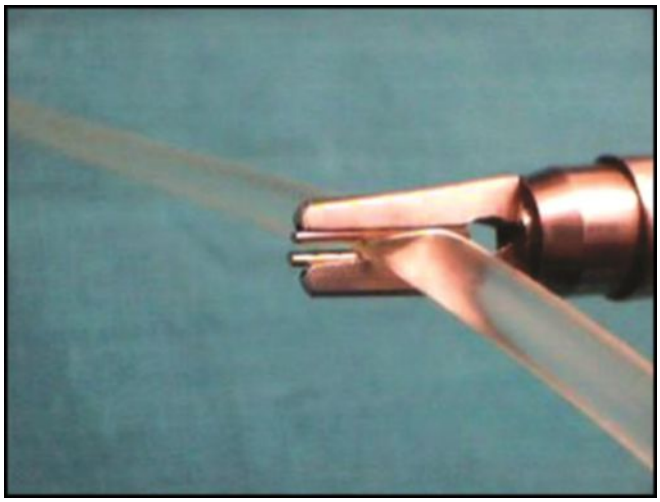


FIG. 8.8: CLIP SHOULD BE KEPT PRESSED FOR 3 SECONDS

CAT EYE STONE

Sometimes clip applied on cystic duct may internalize and it may act as foreign body. In rare cases cat eye stone has been reported with the use of Titanium clips. After many years it stimulates stone formation by deposition of bile. It is called cat eye stone because after taking a cross-section of these stone the titanium clips look like pupil of a cat seen in dark.

LAPAROSCOPIC INTERNAL SUTURING

One of the most challenging aspects of laparoscopic surgery is intracorporeal suturing and knot tying. A loss of depth perception and tactile sense and visual obstruction make placing accurate and well-tied knots a difficult and time-consuming task. The technique for suturing needs to be modified depending on the instrumentation in use. A lot of work is currently being carried out on designs for new needle holders and automatic suturing.

INSTRUMENTATION

The Needle

Endoski needle

Although conventional open surgical needles (half circle) can be used endoscopically, the endoski needle developed in Dundee is designed specifically for endoscopic use and is a hybrid of the straight and half circle needle. It carries an atraumatic suture and has a straight shaft and a terminal tapering curve (that corresponds to ¼ of a circle), giving it the shape of a miniature ski. The shaft is a modified rectangle, which becomes more and more rounded towards the tip so that the curved portion of the needle is round bodied. This combination allows for an easier grip of the shaft by the jaws of the needle holder and smooth passage of the curved portion of the needle through the tissues.

Needle Holders

The most commonly used is 5 mm Cuschieri needle holders. These have single action tapered jaws. The handles are spring loaded and the most recent versions have diamond coating for gripping the suture material without damage. A relaxed “open hand” grip is strongly recommended for these instruments. Please note that there are a wide variety of needle holders

(or drivers). In practice, it is vital for each surgeon to become accustomed to a particular type and use that pair all the time. This is crucial for efficient and safe suturing.

Needle Control

Introduction into the Body Cavity

We recommend the use of the introducer tube to protect all ligatures and sutures from the cannula valve mechanisms.

The suture material on the endoski needle is trimmed to a suitable length. For a continuous suture this will be approximately 15 to 20 cm (Fig. 8.9).

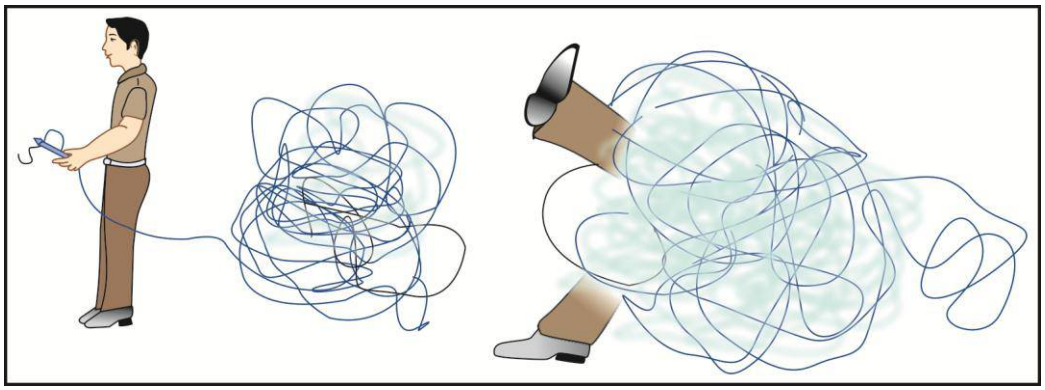


Fig. 8.9: The length of suture should not be more than 20 cm

The *suture length must never exceed 20 cm* as this will result in very difficult intracorporeal suturing since the length is magnified (2.5 times) by the imaging system.

The needle holder is first passed through an introducer tube. The tail of the suture is held next to the tip of the needle and the suture picked up by the needle holder at its mid point. It is then withdrawn into the introducer tube until neither the needle nor the tail is visible. The introducer tube can then be passed through a port and the needle extruded from the tube. The suture is watched into the abdomen and placed on a convenient surface, e.g. the flat, smooth anterior surface of the stomach.

To Insert the Needle

- Pass the needle holder through the reducing tube.
- Pick up the suture material with the needle holder at a point mid way from the tip of the needle and the tail of the thread.
- Withdraw the suture and needle inside the tube so that it is completely out of sight.
- Insert the tube through an appropriate port.
- Extrude the needle and suture from the tube by advancing the needle holder and position on a safe surface, e.g. the anterior surface of the stomach.

Manipulation

- A trailing needle is a safe needle.
- A held needle should always be in view.
- Tips of the two needle holders must always be in view.
- Two needle holders must never cross each other by moving parallel to each other from one side to the other.

The ability to maneuver the needle into the desired position in the needle holder jaw is one of the first skills you must acquire. It is well worth practicing the techniques for this as it will make all subsequent tasks much easier. This task causes much frustration until it can be achieved at will.

The first step is to arrange the needle to the required orientation on the tissues (preferably on a serosal surface and not fatty tissue). Recommended techniques to get the needle in the right attitude on the tissues include the "nudge", the "push", and the twist" techniques. This maneuver should be better demonstrated for learning.

Position

The needle must next be positioned correctly in the jaws of the needle holder. Ideally the needle is grasped in the right orientation by the tips of the jaws. It is a mistake to grasp the needle by the back of the jaws as this impairs precision needle driving through the tissues and also reduces the grasping force so that needle swivel is more likely.

For a right handed surgeon in a straight forward situation, the needle is held in the right hand needle (RH) holder with the tip pointing to the left. The tip of the needle points upward and the shaft of the needle should make an obtuse angle with the shaft of the holder.

The key elements in achieving this are:

- The needle position on the tissues
- The angle of approach of the holder
- The pick up actions.

Adjustments to the angle can be made using:

- Other needle holder
- Surrounding tissue
- Tensioned suture material.

Passage Through the Tissues

Position the needle appropriately in the needle holder and identify the position of the first entry point. Place the tip of the needle at this position so that the sharp tip enters the tissue at right angles.

When approximately 1/2 of the curve of the needle has entered the tissue (corresponding to 2.0 mm) the wrist is supinated and lifted slightly to passage the curved section of the needle through the tissue. When the point of the needle is seen to emerge at the exit point, the grasp is maintained and the needle end (not tip) is grasped by the other (assisting) needle holder before it is released by the dominant needle holder. For the second bite (in other tissue edge) the dominant needle holder can retrieve the needle directly from the assisting needle holder provided the needle is in a favorable position for direct transfer. Otherwise it is more ergonomic to drop the needle and pick it up by the dominant holder. Once the two edges have been passaged, the needle is dropped and the suture pulled to the desired point by an instrument to instrument technique through the tissues. A trailing needle does less harm than one that is held rigid in the holder. A grasped needle must always be in view.

Tensioning

A continuous suture is initially tensioned by pulling through the suture material. Further tightening can be achieved by use of the dominant needle holder although one must be careful

not to fray or damage the suture. The open jaws of needle holder are placed on the side of the suture as it exits from the tissues. They can then be used to apply counter pressure on the tissues as the suture is pulled tight by the assisting needle driver. Tension in a suture line is then maintained by occasional locking sutures and the appropriate use of an assistant. In clinical practice, tension on the suture line is kept by the assistant using a special suture holder that does not damage the suture which has rounded jaws.

Microsurgical Tying

This is a precise choreographed set of actions. Each maneuver is designed to help make the whole process smooth and reproducible with economy of movement and structured choreography, so that suturing is efficient with minimum of wasted time. Note the following important points.

- The passive and active role of the holders
- The formation of the initial "C"
- Its relation to the tail of the suture
- The conscious assessment of position
- The use of the natural bias of the thread
- Appropriate rotations of the needle active and passive needle holder that must be manipulated in consort
- Note the importance of keeping the ends of the two needle holders in the operative field
- Note the importance of two-handedness for efficient suturing.

Steps of Surgeons Knot (Figs 8.10A to H)

- A "C" loop is made.
- The instrument of the side of "C" should be kept above the "C" and two winds are taken with the help of right instrument.
- Winds are slipped in the line of left instrument.
- Knot is tightened with the help of both the instruments.
- First knot of surgeons knot is complete.
- A reverse "C" is made and single wind is taken over the right instrument with the help of left instrument.
- Again "C" loop is made and single winds are taken to complete surgeons knot.
- Surgeons knot contains double wrap on the first throw, followed by two opposing, alternating single throws.

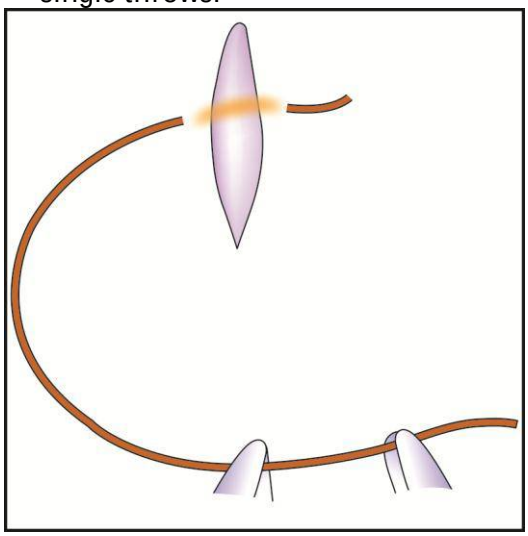


Fig. 8.10A

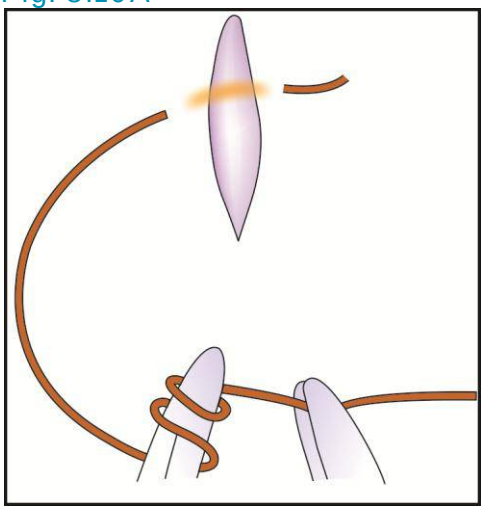


Fig. 8.10B

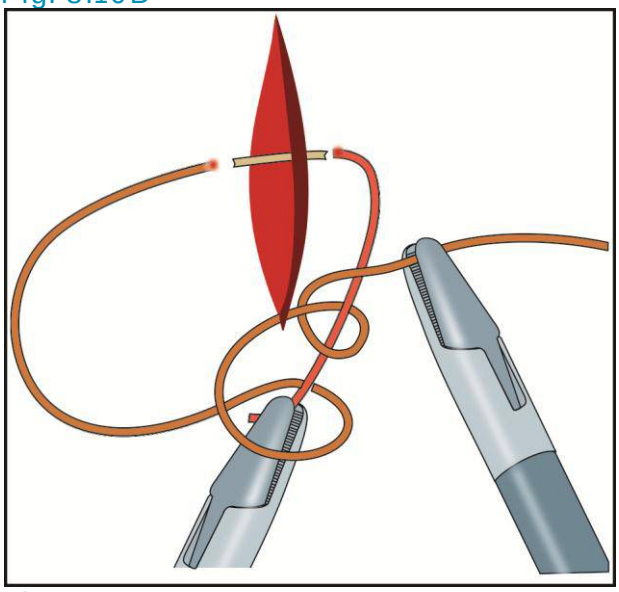


Fig. 8.10C

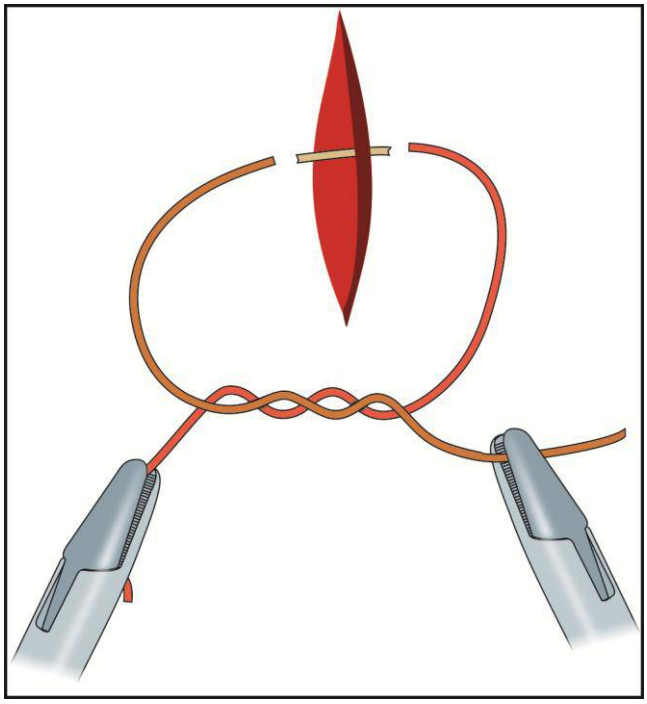


Fig. 8.10D

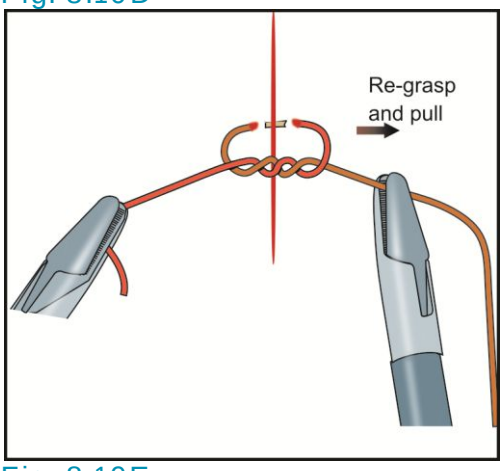


Fig. 8.10E

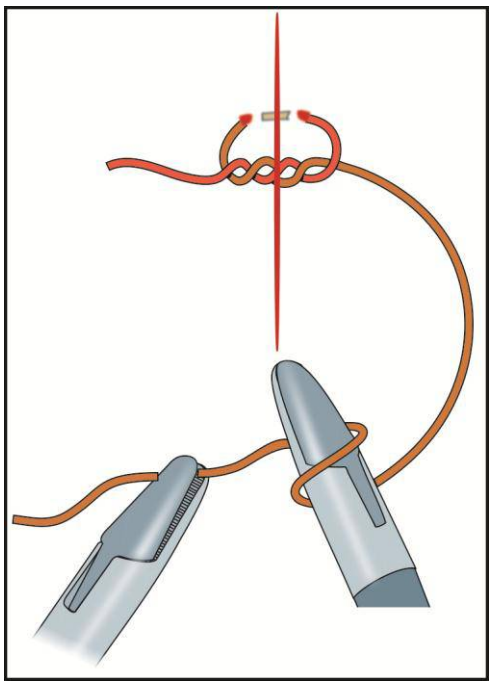


Fig. 8.10F

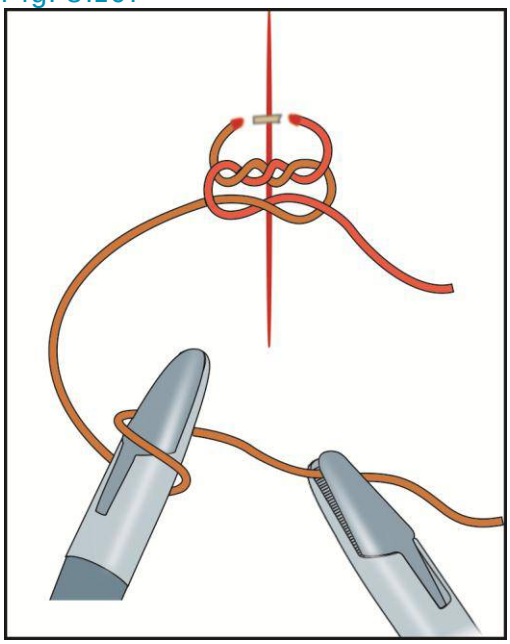


Fig. 8.10G

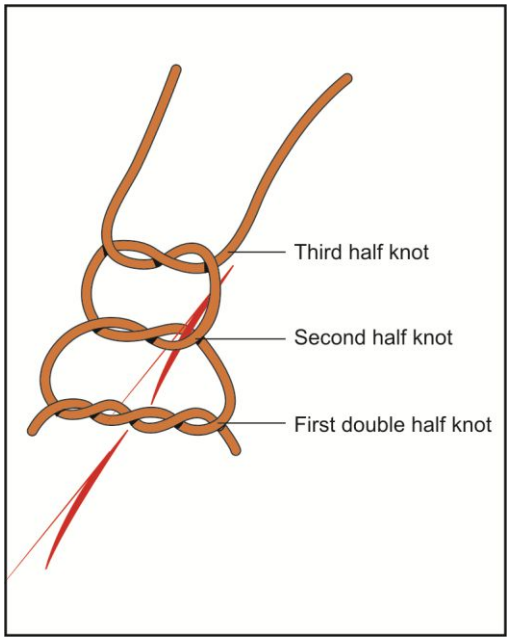


Fig. 8.10H

Figs 8.10A to H: Various steps of surgeons knot

Tumble Square Knot (Figs 8.11A to G)

This is a simple square knot which can be changed to slipping configuration by tightening of a same side of thread.

- A square knot is tied.
- Same side of thread should be straightened with the help of two Maryland or needle holders.
- After straightening of same side of thread it is ready to slide.
- Closed jaw of Maryland forceps will slide the knot.
- After tightening, the knot is locked again by pulling both the thread.
- One more knot is tied to prevent slipping of tumble square knot.

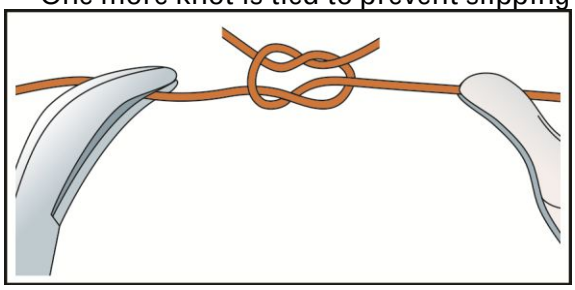


Fig. 8.11A

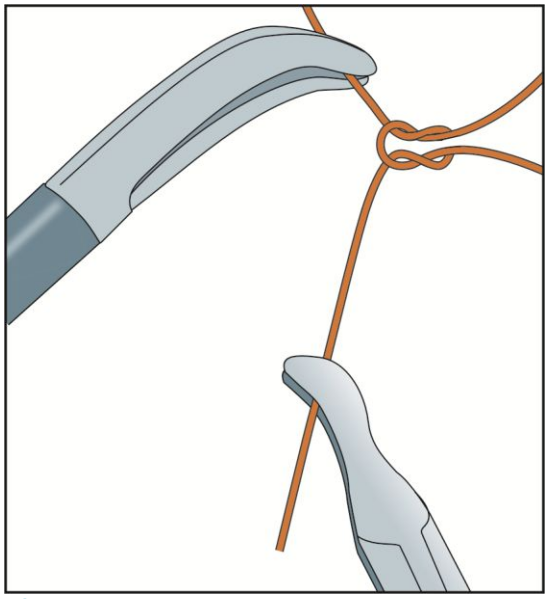


Fig. 8.11B

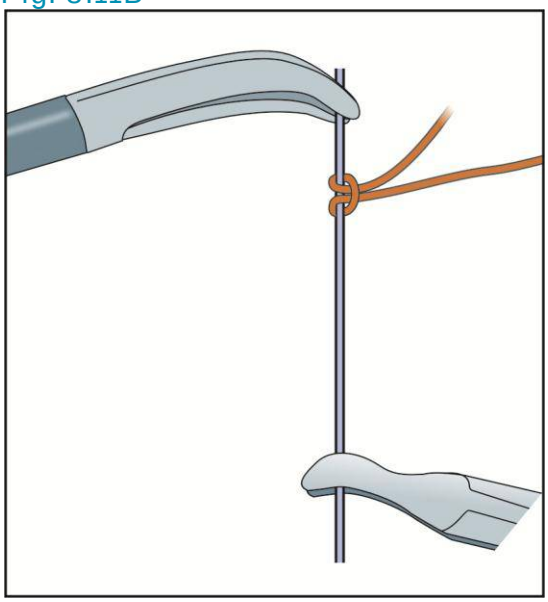


Fig. 8.11C

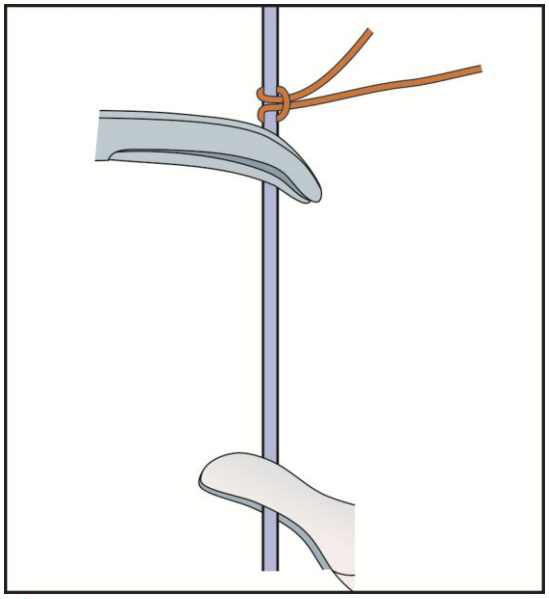


Fig. 8.11D

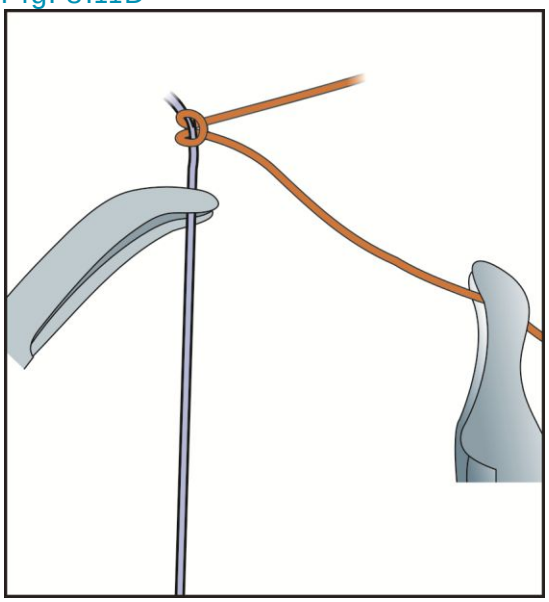


Fig. 8.11E

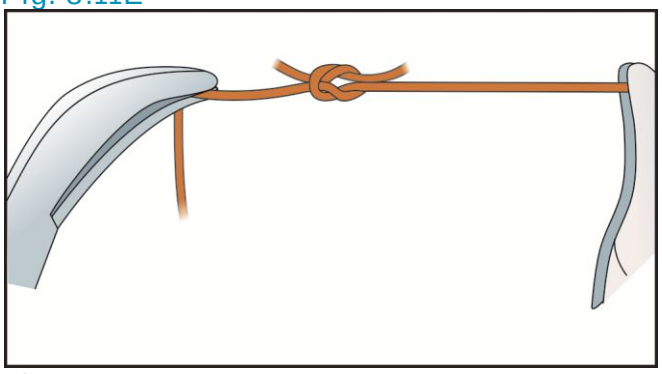


Fig. 8.11F

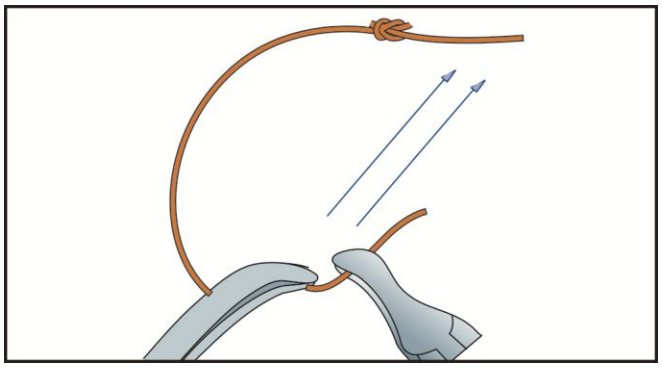


Fig. 8.11G
Figs 8.11A to G: Various steps of Tumble square knot

CONTINUOUS SUTURING

It is common practice to start a continuous suture with a Dundee Jamming Slip knot. An equally acceptable alternative is an internal tied knot if the surgeon is proficient.

A continuous suture can be finished in a number of ways. We recommend the Aberdeen termination, an internal tie to a convenient tail or a slipping loop tied to itself.

Dundee Jamming Slip Knot

This is a recommended way of starting a continuous suture. This knot has an external component but is completed, once inside the body cavity, after the first bite of tissue have been taken.

The external component has following steps:

- A simple slipping loop
- Passage of the tail through the first loop
- Creating a second loop
- Tensioning of the second loop.

The second loop should slip only from the tail, the knot should not be tightened at this stage and the length of both the loop and of the tail should be at least 1 cm.

Once inside, the knot is locked by passage of the standing part of the suture through the loop, which is then slipped to lock the knot.

Starting a Continuous Suture

- Tie the external component of the Dundee jamming slip knot at the end of an atraumatic suture or start with and intracorporeal surgeons knot.
- Pass an atraumatic grasper through an introducer tube.
- Pick up the suture at a point mid way from the tail of the suture to the needle tip.
- Draw suture and needle completely inside the introducer tube, being careful not to slip the Dundee jamming slip knot.
- Pass the introducer through the 11 mm cannula.
- Extrude the suture and deposit it on a safe surface (e.g. the anterior surface of the stomach).
- Pick up the needle and take the first bite of the tissue or tissues to be sutured.
- Pull the thread through until the Dundee jamming slip knot just impinges on the tissue.
- Pass the needle holder carefully through the loop of the Dundee jamming slip knot and pick up the thread attached to the needle at a point near to its exit from the tissues.
- Pull the needle holder and thread with the trailing needle back through the loop.

- Next take hold of the tail of the loop and the standing part of the thread and pull first on the tail and then on the standing part, locking the knot.
- Trim the tail. You are now ready to start your continuous suture.

APPLICATIONS

It is used in any continuous suture, e.g. closure of viscerotomies following stapled anastomosis, sutured anastomosis such as cholecystojejunostomy, gastrojejunostomy, etc. It can also be used as an interrupted suture, when additional one or two hitches are advised for security (in our practice an internally tied knot would be used in preference for an interrupted suture).

Aberdeen Termination

This is an adaptation of a termination commonly used in abdominal closure following open surgery. The continuous suture is finished by the formation of three interlocking loops. In order to simplify the maintenance of tension in the suture line, the penultimate stitch can be locked. A further bite is then taken and the suture pulled through, though not completely. A small loop of suture is left, enough that the needle holder can be passed through it to pick up the standing part of the suture. A loop of this is then drawn through the first loop, which is tightened down onto the tissues. The needle holder is then passed through the new loop to repeat the maneuver three times.

It is important that each loop be tightened as you proceed. To do this, tension must be applied to the leg of the loop, which exits, from the tissues or the preceding loop.

The standing part and needle are delivered completely through the last loop. The standing part is held up and the suture tensioned with counter pressure from the jaws of the needle holder placed on either side of the suture. The suture is cut off leaving a reasonable length (approximately 1 cm).

INTERRUPTED SUTURES

Interrupted Knots

Dundee jamming loop knot is used to create interrupted sutures. For additional safety a further hitch or two are recommended if it is to be used as an interrupted suture. More commonly interrupted intracorporeal sutures are made by the use of the surgeon's or the Tumbled square knots.

Applications of Interrupted Sutures

Interrupted sutures have a multitude of uses. Simple examples are closure of the common bile duct after exploration and fundoplication.

Stapled Anastomosis

The use of disposable stapling guns has simplified a number of endoscopic procedures such as the division of vascular pedicles and gut anastomosis.

The following important points are emphasized:
- Port positions for stapling
- Stay sutures for tensioning
- Enterotomy positioning and size
- Positioning and angulations of the instrument prior to closure

- Checking suture line
- Complete closure of residual opening
- End to end anastomosis can also be carried out by stapling closed bowel ends side by side.

Clinical Applications

An anterior or posterior, side to side anastomosis of stomach and jejunum done laparoscopically can be a satisfactory palliative procedure. Likewise, a laparoscopic cholecystojejunostomy may be performed with stapler to relieve jaundice and itching in patients with inoperable pancreatic cancer.

SUTURED ANASTOMOSIS

Sutured anastomosis can be carried out endoscopically, although the process is demanding in terms of skill and time. However, it is pertinent to note that staplers may not always be available, or appropriate, and even if a stapler is used, you require the skills to perform a sutured closure if the stapled anastomosis is not perfect.

Important points to remember are:
- Port positioning
- Use of communication with your assistant
- Positioning of sutures, especially at the corners
- Spacing the sutures (remember the magnification)
- Tensioning of sutures.

Direction of Suturing

It is important that you suture at the right height, ideally your elbows should be held adducted and at right angles. Keep your wrists loose and remember that you have two hands that must manipulate to help each other. The choreography is as follows:
- The suturing line is started with a 'starter knot' (surgeons or tumbled square knot).
- The two needle holders must be kept in view and used in concert with each other.
- Passage from right to left through the tissue edges (bites consisting of entry and exit points with dominant needle holder.
- The needle is picked up from the exit point by the passive needle holder (NH).
- It is transferred to dominant needle holder for the next bite if the orientation is correct. Otherwise it is dropped and re-orientated in the needle holder. Once the suture has passed through the two edges, the thread is pulled trough, handing the suture one needle holder to the other.
- The distance between the suture bites must be approximately equal to the depth of the bites.

TECHNIQUES TO ASSIST IN CONTROL OF BLEEDING

Methods of Securing Hemostasis

Endoscopic surgery is controlled almost entirely by vision. Any loss of view will result in loss of control and a reduction in safety. Hemorrhage, even to a minor extent, tends to obscure the operative field and consequently to be avoided. This means that vessels of a size that in open surgery could be divided without particular attention need to be secured prior to division when working endoscopically. Dissection must be more meticulous to proceed smoothly and you must develop a disciplined approach.

Magnification of tissues by the endoscope may initially confuse an inexperienced endoscopic surgeon as to the severity of the bleeding. A moderate bleed can appear torrential but an inexperienced endoscopic surgeon is well advised to convert should he have any doubt about his ability to control the situation quickly.

- Pressure on the area applied by grasping adjacent tissue, and using this to overly and apply gentle pressure on to the area.
- Compression with pledget swab if the bleeding is not heavy until hemostasis is achieved by clipping or electrocoagulation and the sucker.
- Suction/irrigation to identify the bleeding point prior to securing it.
- Under-running by suture if the bleeding point cannot be identified.
- Argon spray coagulation for raw bleeding areas.
- Occluding the vessel with graspers before clipping it.
- Application of fibrin and other glues or hemostatic agents.

Avoid Blind Coagulation

Control the initial bleeding and then take your time to identify the bleeding point. In anatomically crowded areas containing important structures, it may be advisable to allow time for the bleeding to stop by compression for one or two minutes. If bleeding cannot be controlled inside within 5 minutes, serious consideration should be given for conversion to open surgery. This period should be shorter if bleeding is massive or arterial.

Suction and Irrigation

The availability of suction and irrigation is as important for hemostasis in endoscopic surgery as gauze swabs are in open surgery. When bleeding does occur irrigation can assist in visualization of the bleeding point and suction removes pooled blood and clears clots from the operative site. In addition, the irrigation activates Hageman factor and thus initiates spontaneous hemostasis.

Heparanized Hartmann's solution (1000 units per 500 ml bag) is ideal if clots are present. This solution is preferred to normal saline because of its lesser conductivity, an important consideration when using monopolar HF electrocautery. The heparin also reduces the stickiness of the instruments and thus improve handling especially of suture and ligature materials. It also aids removal of pooled blood. The bag of fluid is placed in a Fenwell pressure bag raised to 200 mm Hg and hung from a drip stand. As the contents of the bag are used the pressure needs to be maintained. There are several pressurized irrigation systems available, some heat the irrigating fluid to body temperature, other provide pulse irrigation which is helpful from breaking up blood clots and cleaning the peritoneal gutters.

Suction and irrigation are also essential to deal with leakage from ultra-abdominal organs, e.g. bile leakage, bowel content, perforated ulcer, appendicitis. In these acute emergency situations, laparoscopic abdominal lavage of the peritoneal quadrants is aided by shaking the patient from side to side and changing the position of the operating table (head up, head down and sideways).

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