10.5005/jp-journals-10033-1221

ORIGINAL ARTICLE

# Is There an Ideal Port Position for Laparoscopic Urological Procedures?

[1]Bashir Yunusa, [2]RK Mishra, [3]JS Chowhan


## ABSTRACT

**Background:** Reports have suggested increased use of laparoscopy in the treatment of urological diseases and equally wrong port positions as the commonest cause of struggling during surgeries and increased in complications and operative time.

**Aim:** We aimed to find out the ideal positions for laparoscopic ports to be placed during urological procedures.

**Methods:** We performed different laparoscopic tasks in both the upper and lower urinary tract regions, at different ports position making different manipulation angles and operative time recorded. The procedures were performed on both dry and wet laboratory and on human during laparoscopic donor nephrectomies.

**Results:** The average operative time of those ports whose position approximate to manipulation angle of 60º was shorter and more comfortable to the surgeons.

**Conclusion:** There is no ideal positions for port placement in urological procedures based on anatomical landmarks, but rather any position that approximate its manipulation angle to as close to 60º as possible.



**Keywords:** Port positioning, Manipulation angles, Laparoscopic urological.

**How to cite this article:** Yunusa B, Mishra RK, Chowhan JS. Is There an Ideal Port Position for Laparoscopic Urological Procedures? World J Lap Surg 2014;7(2):74-87.

**Source of support:** Nil

**Conflict of interest:** None


## INTRODUCTION

### Laparoscopic Nephrectomy and Port Positioning

There are various approaches to nephrectomy and the placement of ports depends on the approach and the side, and whether or not a single site laparoendoscopic approach is intended.

### Transperitoneal Approach

In this approach, usually a 12 mm port is placed at umbilicus by open Hasson technique, which is often primarily used as a camera port. Another 12 mm laparoscopic port is placed between umbilical port and anterior superior iliac spine (spinoumbilical port) and a 5 mm port is placed in line with the camera port at about 3 cm below the costal margin and 3 cm lateral to the midline. The fourth usually for retraction if needed, is a 5 mm port placed 4 cm below the costal margin in anterior axillary line.[1-6] Both kidneys have similar approach on either side.

Another approach is to place the laparoscopic port on the midclavicular line just at or above the upper border of the umbilicus. A working port usually 10/12 mm is positioned a fingerbreadth below the costal margin on the anterior axillary line. A second working port, is placed on the anterior axillary line just above the superior iliac crest. An additional working port may be placed on the midaxillary line midway between the costal margin and the superior iliac crest to provide access for a retracting instrument and to mobilize the kidney laterally. For the extremely thin patient the port sites are all moved medially with the laparoscope at the umbilicus, the working ports on the midclavicular line and an additional port on the anterior axillary line.[8]

One other approach for the left kidney is to place the camera port at the paraumblical space at the lateral border of the rectus muscle at the level of the umbilicus while the patient is placed in the right lumbotomy position; through the open introduction technique according to Hasson. One additional 10 mm and one 5 mm trocar are then inserted under laparoscopic vision in the epigastric and midclavicular positions.[9]

The left kidney can also be approached with the camera port placed just to the left of the umbilicus. The left hand 12 mm port placed along the lateral border of the rectus abdominis muscle lateral to the umbilicus. The right hand port placed on the lateral border of the rectus near the dome of the bladder. A fourth port to be placed laterally to retract the sigmoid colon medially.[10]

### The Retroperitoneal Approach to the Kidneys

In the retroperitoneal laparoscopic approach, incision is made at tip of 12th rib and then blunt dissection or balloon used to create space and the working port is placed between the midaxillary line and the anterior axillary line (5 cm above the iliac crest). A 5 mm port is then inserted at the junction of the 12th rib and paraspinal muscles (renal angle).[11]


[1]Senior Registrar, [2]Professor, [3]Consultant

[1]Department of Surgery, Division of Urology, Aminu Kano Teaching Hospital, Kano, Nigeria

[2]Minimal Access Surgery, World Laparoscopy Hospital, Gurgaon Haryana, India

[3]Department of Laparoscopic Surgery, World Laparoscopy Hospital, Gurgaon, Haryana, India

**Corresponding Author:** Bashir Yunusa, Senior Registrar Department of Surgery, Division of Urology, Aminu Kano Teaching Hospital, Kano, Nigeria, e-mail: bashrano@gmail.com

Another approach through the retroperitoneal space is obtained through a 15 to 20 mm incision just below the tip of the 12th rib and the secondary ports are then placed along the inferior border of the costal margin using digital palpation through the balloon dilated incision site. After digital placement of all the secondary ports, the primary balloon-tip port is inserted. The posterior secondary 12 mm port is placed at the lateral border of the paraspinal muscle along the inferior border of the 12th rib. An anterior port is placed near the anterior axillary line, just below the inferior tip of the 11th rib. An additional 5 mm port may be placed, on the midaxillary line at or above the level of the superior iliac crest, and used for retraction and suction. Often a 12 mm port is placed at Petit's triangle just above the midportion of the iliac crest and a fingerbreadth superior to the iliac crest.[8]

### Hand-assisted Laparoscopic Nephrectomy

The hand-assisted device for right renal surgery could be located at and just below the umbilicus on the midline. Alternatively, on the right side, the hand port may be placed as a Gibson incision in the right lower quadrant. A port is placed on the midclavicular line just above the superior iliac crest; the laparoscope is positioned at this port site. A 12 mm port is placed two fingerbreadths below the costal margin on the midclavicular line, to accommodate the Endo-GIA stapling device. A 5 mm port is placed on the midline in the epigastric region for placement of an instrument to retract the liver superiorly and medially.[8]

Conversely, on the left the incision for the hand-assisted laparoscopic (HAL) device is located on the midline, at and above the umbilicus on the midclavicular line just above the superior iliac crest, a 10 mm port placed for positioning of the 10 mm, 30º laparoscope. The laparoscope may then be used for visualization of the HAL device incision. An additional 12 mm working port is placed on the midclavicular line 2 fingerbreadths below the costal margin. Retraction of the kidney laterally may be facilitated by an instrument placed through a 5 mm port in the midaxillary line, midway between the costal margin and superior iliac crest.[8]

### Laparoendoscopic Single Site Nephrectomy

Since the advent of laparoscopy, urologists have tried to minimize scars and improve cosmesis, leading to the progression to laparoendoscopic single site urological procedure. Access is usually gain through the umbilicus, but others include transabdominal or retroperitoneal flank approach, a suprapubic or mini-Pfannenstiel approach or Gibson incisions.[12]

Either a specialized port or cluster conventional port can be used to obtain access. Conventional laparoscopic techniques are generally followed, although modifications in techniques and manoeuvres unique to single site surgeries are employed.[12]

During laparoendoscopic single site (LESS) nephrectomy, a periumbilical incision is made to the rectus fascia. The peritoneum is entered with an extra-long trocar. After pneumoperitoneum, another trocar, is placed 1 to 1.5 cm caudal and at the 4 o'clock position to the extra-long trocar, eventually functioning as the camera port. A 12 mm port is inserted 1.5 cm caudal to the second trocar, resulting in triangular configuration. A fourth 12 mm standard length trocar is placed 1 cm cephalad to the umbilical protuberance, through which liver or splenic retraction and control of the renal upper pole and adrenal gland is achieved.[13]

### Natural Orifice Transluminal Endoscopic Nephrectomy

Natural orifice transluminal endoscopic surgery (NOTES), with the objective of incision free abdominal surgery through natural orifices (mouth, vagina and rectum) has been described. Although, there were reports on successful completion of six laparoscopic transvaginal nephrectomies using conventional instruments in a porcine model, there were note of limitations of the laparoscopic instruments making the procedure cumbersome and time consuming. Clayman et al reported their experience with single port NOTES transvaginal nephrectomy and encountered similar difficulty until a purpose built multi lumen operating instruments were made available.[14]

Hybrid NOTES in which two natural orifices are used for approaches has also been described and tried for nephrectomies. Transvaginal NOTES hybrid combined with either transgastric or transvesical nephrectomy, transvesical-transgastric have all been described.[15]

### Laparoscopic Pyeloplasty

Standard port placement described as ports placed in the upper and lower quadrant midclavicular lines and the camera port placed near the umbilicus. An assistant port is placed in the suprapubic midline.[16]

Another approach with a primary port at 2.5 cm to the right of umbilicus, a 5 mm port midway between the primary port and right costal margin and, on right midclavicular line, and another 5 mm port midway between the anterosuperior iliac spine and the umbilicus was used while the patient was placed in the 45 left lateral position. Fourth flank port is placed for retraction.[17]

### LESS Pyeloplasty

The patient is positioned in a modified flank fashion, and a 2.5 cm incision is made within the umbilical dimple to conceal the scar. After insufflation of the abdomen, three

5 mm trocars are placed through the anterior abdominal fascia in a triangular configuration. A 5 mm 45º laparoscope is used along with articulating laparoscopic instruments. The laparoscope is placed through the most medial trocar and positioned anteriorly in the abdomen so that the camera looks down onto the surgical field. The working instruments are placed through the two lateral trocar.[18]

### Laparoscopic Adrenalectomy

Laparoscopic adrenalectomy (LA) has become a gold standard in the management of most of the adrenal disorders, after it was described by Schuessler et al in 1993 and matched it success with open.[19] Apart from advantages like early recovery, reduced hospital stay and cosmesis, the main benefits of LA over open adrenalectomy are decreased incidence of intraoperative and postoperative hemorrhage, decreased morbidity and mortality.

### Transperitoneal Laparoscopic Adrenalectomy

This involves putting 12 mm port in the umbilicus or at the lateral border of rectus abdominis muscle just above the level of umbilicus. Two subcostal 5 mm ports at midclavicular line and in the lateral border of the rectus and another 3.5 mm subcostal trocar-anterior axillary line, for the left adrenals. The right is approached through a mirror image and an additional epigastric port to the left of the liver for its retraction.[20]

Right adrenalectomy can also be performed with four ports. The primary camera port 10 mm to be placed at about 3 cm lateral and cephalad to the umbilicus. Two working ports, 5 and 10 mm are placed in the midclavicular position, the upper one (5 mm) below the costal margin, and the lower one (10 mm), 10 to 12 cm below the upper one. Another 5 mm port is to be placed in the sub-xiphisternal position for liver retraction. A fifth 5 mm port, if required, is placed in the right anterior axillary line, to facilitate retraction or suction.[20,21]

And another approach is to put the telescope's trocar at the umbilicus while maintaining the positions of the other trocars.[20] In the case of the left usually, the first three ports are placed in a mirror image of the right. A fourth 5 mm port, if required, is placed in the left midaxillary line to facilitate retraction.[20-22]

### Retroperitoneal Lateral Laparoscopic Adrenalectomy

Retroperitoneal lateral approach to the left adrenal gland is through an incision at the inferior edge of the 12th rib in which the camera port is placed, the second port 5 mm at anterior axillary line midway between the iliac crest and costal margin, third port is placed posteriorly between the 12th rib and iliac crest along the lateral border of sacrospinatus muscles and the fourth port for retraction is placed cephalad to the first port at anterior axillary line. The right side is a mirror image of the left but the liver lobe is retracted percutaneously reducing the ports number to three.[23]

Retroperitoneal posterior approach described by Walz et al, and thoracoscopic transdiaphragmatic approach described by Gill et al are not commonly used.[20]

### LESS Adrenalectomy

The approach is usually through transumbilical incision and placement of multichannel single Gelport and 3.5 mm ports for flexible laparoscope, SILS dissector and tissue sealing device; and the adrenal gland approached anteriorly in cases of right side with no mobilization of the right lobe of the liver, and the left is approached laterally.[23] Retroperitoneal LESS adrenalectomy has also been described.

### Laparoscopic Approaches to the Ureter

A three-port approach with primary port at the umbilicus, one 5 mm port midway between the umbilicus and the medial costal margin and a 5 mm port midway between the anterosuperior iliac spine and the umbilicus, was described.[24]

Umbilical port with, ipsilateral hypochondrium and iliac fossa as working ports have been described for approaches to upper and mid ureter while ipsilateral paraumbilical and suprapubic ports for lower ureter while maintaining the umbilical port.[25]

In cases of retrocaval ureter, a three port approach with a primary port at 2.5 cm to the right of umbilicus, a 5 mm port midway between the primary port and right costal margin, and on right midclavicular line, and another 5 mm port midway between the anterosuperior iliac spine and the umbilicus was used while the patient is placed in the left lateral position. Mobilization of the ureter in the interaortocaval region require additional 5 mm port to be inserted at the flank.[17]

LESS approach to lower ureter through suprapubic transvesical port has been described.[26]

### Laparoscopic Prostatectomy

Laparoscopic simple or radical prostatectomy has been performed through almost the same approach. The commonly described conventional laparoscopy is through a primary port placed upper side of the umbilicus. Then secondary ports at upper margin of the pubic bone and levels of the anterior superior iliac spines bilaterally and the fifth port at a point midline at about 15 cm from the pubic bone[27,28] while others described both iliac fossae for the last two ports, most especially when it is to be robotic assisted[29] others described the distance of the second and third ports to be 8 to 10 cm from the camera port.[30]

Transumbilical LESS radical prostatectomy was first described in 2008 by Kaouk et al, through the umbilicus using a single three-channel port, and 2 years later Desai et al published the initial series of single-port transvesical simple prostatectomy where a single-port device inserted percutaneously into the bladder through a 2 to 3 cm incision in the suprapubic skin crease was used.[5]

### Laparoscopic Cystectomy

Laparoscopic cystectomy has been described by many authors, but remains to be evaluated and is far from being a standard procedure. While some described a similar approach to prostatectomy with periumbilical port, two others 8 to 10 cm away from the primary port and then bilateral iliac fossae[31] others described only four ports approach with 3 to 4 cm supraumbilical camera port and two iliac fossae ports and suprapubic port[32] and the sixth port is only needed during urinary diversion in radical surgeries.[33]

In the hand-assisted approach, a 7 cm periumbilical incision is made as the hand port, camera is placed at the left of the hand port in the midclavicular line at the level of the umbilicus, a second port is placed 5 cm below the level of the umbilicus at right midclavicular line. A 10 mm port is placed in the left anterior axillary line and a 5 mm at midline about 5 cm above the pubic symphisis.[34]

Kaouk et al described the laparoscopic radical cystectomy and pelvic node dissection through a single umbilical port and an extracorporeal urinary diversion by way of extension of the umbilical port site.[5]

### Laparoscopic Varicocelectomies

Laparoscopic varicocelectomy is generally performed transperitoneally, but extra or retroperitoneal has also been described. And two trocars or single trocar approaches described, but generally three trocars are required especially in bilateral cases.[35]

Varicocelectomy is performed in a transperitoneal laparoscopic fashion with two ports placed at supraumbilical and caudal and lateral to the umbilicus on the contralateral side of the varicocele.[36]

For the three ports approach, some described the subumbilical camera port with secondary trocars at midline half way between umbilicus and pubic symphysis, and the other at midclavicular line 1 to 2 cm below horizontal line to the umbilicus while maintaining subumbilical camera port[37] while others described umbilical primary port and both lower abdominal quadrants ports.[38,39]

### Mitrofanoff

A four-port transperitoneal approach is described, with camera at umbilicus, two 5 mm at left lower quadrant and right midaxillary line at the level of the umbilicus. Fourth port at left midaxillary also at umbilical level.[40]

### Other LESS Procedures

Single site laparoscopic surgery has been reported in small numbers for a variety of other urological conditions. A mesh sling has been successfully removed from the bladder via a transvesical approach. Sacrocolpopexies, orchidopexy and orchidectomy have been successfully performed through a single incision without complication.[5]

## DISCUSSION

*First:* Tables 1A to D showed readings of timing obtained while making a surgeon's knot in the region of upper urinary tract in the dummy at different manipulation angles which were validated by $\chi^2$ tests and average obtained. The average timing in seconds for 30, 60 and 90º were 221.20, 130 and 283.95 respectively. Although all the readings were reproducible at p-value (30.144), 5% level of significance:

**Table 1A:** Timing for surgeon's knotting in upper urinary track with manipulation angle 30º

| *Sl no.* | *Observed (O)* | *Expected (E)* | *O-E* | *$(O-E)^2$* | *$(O-E)^2/E$* |
|---|---|---|---|---|---|
| 1 | 249 | 221.20 | 27.8 | 772.88 | 3.49 |
| 2 | 206 | | –15.2 | 231.04 | 1.04 |
| 3 | 220 | | –1.2 | 1.44 | 0.01 |
| 4 | 212 | | –9.2 | 84.64 | 0.38 |
| 5 | 239 | | –17.8 | 316.84 | 1.43 |
| 6 | 232 | | –21.2 | 116.64 | 0.53 |
| 7 | 200 | | 27.8 | 449.44 | 2.03 |
| 8 | 249 | | –11.2 | 125.44 | 3.49 |
| 9 | 210 | | 11.8 | 209.44 | 0.57 |
| 10 | 233 | | –11.8 | 139.24 | 0.63 |
| 11 | 204 | | –17.2 | 295.84 | 1.33 |
| 12 | 210 | | –11.2 | 209.44 | 0.57 |
| 13 | 223 | | 1.8 | 3.24 | 0.01 |
| 14 | 222 | | 0.8 | 0.64 | 0.01 |
| 15 | 199 | | –22.8 | 492.84 | 2.23 |
| 16 | 206 | | –15.2 | 231.04 | 1.04 |
| 17 | 254 | | 32.8 | 1075.84 | 4.86 |
| 18 | 201 | | 20.2 | 408.04 | 1.84 |
| 19 | 239 | | 17.8 | 316.84 | 1.43 |
| 20 | 216 | | –5.2 | 27.04 | 0.12 |
| | Average timing = 221.20 | | | | $\chi^2$ = 27.06 |

p-value (30.144) > $\chi^2$, data are reproducible it has clearly demonstrated that the 60º angle has shorter operative time followed by 30 and then 90º. This is shown in Graph 1 (Figs 1 and 2).

**Table 1B:** Timing for surgeon's knotting in upper urinary track with manipulation angle 60º

| *Sl. no.* | *Observed (O)* | *Expected (E)* | *O-E* | *$(O-E)^2$* | *$\frac{(O-E)^2}{E}$* |
|---|---|---|---|---|---|
| 1 | 120 | 130.00 | –10 | 100 | 0.77 |
| 2 | 131 | | 1 | 1 | 0.01 |
| 3 | 118 | | –12 | 144 | 1.11 |
| 4 | 128 | | –2 | 4 | 0.03 |
| 5 | 160 | | 30 | 900 | 6.92 |
| 6 | 138 | | 8 | 64 | 0.49 |
| 7 | 127 | | –3 | 9 | 0.07 |
| 8 | 140 | | 10 | 100 | 0.77 |
| 9 | 120 | | –3 | 9 | 0.07 |
| 10 | 127 | | 11 | 121 | 0.93 |
| 11 | 141 | | 8 | 64 | 0.49 |
| 12 | 138 | | 6 | 36 | 0.28 |
| 13 | 136 | | 8 | 64 | 0.49 |
| 14 | 138 | | 6 | 36 | 0.28 |
| 15 | 113 | | –17 | 289 | 2.22 |
| 16 | 119 | | –11 | 121 | 0.93 |
| 17 | 129 | | –1 | 1 | 0.01 |
| 18 | 130 | | 0 | 0 | 0.00 |
| 19 | 129 | | –1 | 1 | 0.01 |
| 20 | 131 | | 1 | 1 | 0.01 |
| | Average timing = 130.00 | | | | $\chi^2$ = 15.88 |

p-value (30.144) > $\chi^2$, so data are reproducible

**Table 1C:** Timing for surgeon's knot in upper urinary track with manipulation angle 90º

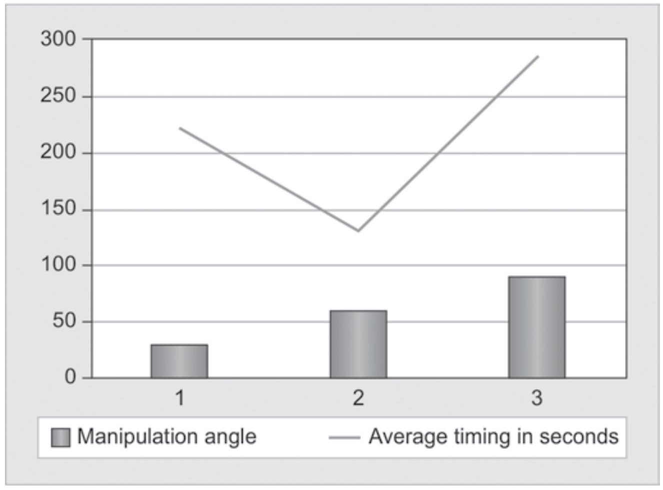
| *Sl. no.* | *Observed (O)* | *Expected (E)* | *O-E* | *$(O-E)^2$* | *$\frac{(O-E)^2}{E}$* |
|---|---|---|---|---|---|
| 1 | 275 | 283.95 | –8.5 | 80.10 | 0.28 |
| 2 | 270 | | –13.95 | 194.60 | 0.69 |
| 3 | 296 | | 12.05 | 145.20 | 0.51 |
| 4 | 305 | | 21.05 | 443.10 | 1.56 |
| 5 | 268 | | –15.95 | 254.40 | 0.90 |
| 6 | 262 | | –21.95 | 481.80 | 1.70 |
| 7 | 271 | | –12.95 | 167.70 | 0.59 |
| 8 | 265 | | –18.95 | 359.10 | 1.26 |
| 9 | 281 | | –2.95 | 8.70 | 0.03 |
| 10 | 281 | | –2.95 | 8.70 | 0.03 |
| 11 | 320 | | 36.05 | 1299 | 4.58 |
| 12 | 270 | | –13.95 | 194.60 | 0.69 |
| 13 | 290 | | 6.05 | 36.60 | 0.13 |
| 14 | 298 | | 14.05 | 197.40 | 0.70 |
| 15 | 273 | | –10.95 | 119.90 | 0.42 |
| 16 | 268 | | –15.95 | 254.40 | 0.90 |
| 17 | 315 | | 31.05 | 964.10 | 3.40 |
| 18 | 309 | | 25.05 | 964.10 | 2.21 |
| 19 | 294 | | 10.05 | 101.00 | 0.36 |
| 20 | 268 | | 15.95 | 254.40 | 0.90 |
| | Average timing = 283.95 | | | | $\chi^2$ = 0.90 |

p-value > $\chi^2$, so data are reproducible

*Second:* Tables 2A to D showed readings of timing taken to clip a renal vessel in the swine at different manipulation angles which were validated by $\chi^2$ test and average obtained. The average timing in seconds for 30, 60 and 90 degree were 16.00, 11.10 and 30.20 respectively. Although,

**Table 1D:** Average timing of surgeon's knotting in the region of the upper urinary tract with respective manipulation

| | | | |
|---|---|---|---|
| Manipulation angle | 30 | 60 | 90 |
| Average timing in seconds | 221.20 | 130.00 | 283.95 |
| $\chi^2$ | 27.06 | 15.88 | 21.81 |




**Graph 1:** Average timing of surgeon's knotting in upper urinary tract

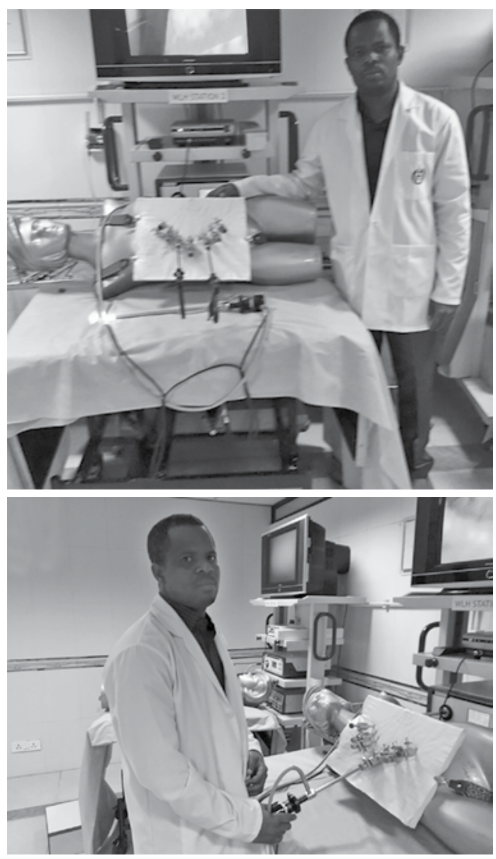


**Fig. 1:** The ports positioning for the upper tract tasks on the dummies

**Table 2A:** Timing of clipping of renal vessels at 30º manipulation angle

| *Observed timing (O) (in sec)* | *Expected (E)* | *O-E* | *(O-E)²* | *(O-E)²/E* |
|---|---|---|---|---|
| 16 | 16 seconds | 0 | 0 | 0.00 |
| 15 | | 1 | 1 | 0.06 |
| 22 | | 6 | 36 | 2.25 |
| 14 | | −2 | 4 | 0.25 |
| 16 | | 0 | 0 | 0.00 |
| 13 | | −3 | 9 | 0.56 |
| 17 | | 1 | 1 | 0.06 |
| 18 | | 2 | 4 | 0.25 |
| 19 | | 3 | 9 | 0.56 |
| 15 | | −1 | 1 | 0.06 |
| 17 | | 1 | 1 | 0.06 |
| 16 | | 0 | 0 | 0.00 |
| 14 | | −2 | 4 | 0.25 |
| 15 | | −1 | 1 | 0.06 |
| 13 | | −3 | 9 | 0.56 |
| 16 | | 0 | 0 | 0.00 |
| 14 | | −2 | 4 | 0.25 |
| 10 | | −6 | 36 | 2.25 |
| 21 | | 5 | 25 | 1.56 |
| 19 | | 3 | 9 | 0.56 |
| | Average time in seconds = 16 | | | $\chi^2$ = 9.56 |

p-value (30.144) > $\chi^2$, so data are reproducible

**Table 2B:** Timing of renal vessels clipping with manipulation angle of 60º

| *Observed timing (O) (in seconds)* | *Expected (E)* | *O-E* | *(O-E)²* | *(O-E)²/E* |
|---|---|---|---|---|
| 13 | 11.1 | 1.9 | 3.61 | 0.33 |
| 11 | | – 0.1 | 0.01 | 0.00 |
| 19 | | 7.9 | 62.41 | 5.62 |
| 11 | | – 0.1 | 0.01 | 0.00 |
| 10 | | – 1.1 | 1.21 | 0.11 |
| 16 | | 4.9 | 24.01 | 2.16 |
| 9 | | – 2.1 | 4.41 | 0.39 |
| 8 | | – 3.1 | 9.61 | 0.87 |
| 9 | | 2.1 | 4.41 | 0.39 |
| 9 | | – 2.1 | 4.41 | 0.39 |
| 11 | | – 0.1 | 0.01 | 0.00 |
| 12 | | 0.9 | 0.81 | 0.07 |
| 11 | | – 0.1 | 0.01 | 0.00 |
| 12 | | 0.9 | 0.81 | 0.07 |
| 12 | | – 0.9 | 0.81 | 0.07 |
| 11 | | 0.1 | 0.01 | 0.00 |
| 10 | | – 1.1 | 1.21 | 0.11 |
| 10 | | – 1.1 | 1.21 | 0.11 |
| 10 | | – 1.1 | 1.21 | 0.11 |
| 8 | | – 3.1 | 9.61 | 0.87 |
| | Average time = 11.1 | | | $\chi^2$ = 11.66 |

p-value > $\chi^2$, so data are reproducible

**Table 2C:** Timing for renal vessel ligation with manipulation angle 900

| *Sl. no.* | *Observed time in seconds (O)* | *Expected time in seconds (E)* | *O-E* | *(O-E)²* | *(O-E)²/E* |
|---|---|---|---|---|---|
| 1 | 32 | 30.2 | 1.8 | 3.24 | 0.08 |
| 2 | 37 | | 6.8 | 46.24 | 1.53 |
| 3 | 25 | | −5.2 | 27.04 | 0.90 |
| 4 | 34 | | 3.8 | 14.44 | 0.48 |
| 5 | 29 | | −1.2 | 1.44 | 0.05 |
| 6 | 29 | | −1.2 | 1.44 | 0.05 |
| 7 | 27 | | −3.2 | 10.24 | 0.34 |
| 8 | 18 | | −12.2 | 148.84 | 4.93 |
| 9 | 33 | | 2.8 | 7.84 | 0.26 |
| 10 | 36 | | 5.8 | 33.64 | 1.11 |
| 11 | 29 | | 1.2 | 1.44 | 0.05 |
| 12 | 27 | | −3.2 | 10.24 | 0.34 |
| 13 | 35 | | 4.8 | 23.04 | 0.76 |
| 14 | 28 | | −2.2 | 4.40 | 0.15 |
| 15 | 32 | | 1.8 | 3.24 | 0.08 |
| 16 | 37 | | 6.8 | 46.24 | 1.53 |
| 17 | 25 | | −5.2 | 27.04 | 0.90 |
| 18 | 24 | | −6.2 | 38.44 | 1.27 |
| 19 | 38 | | 7.8 | 60.84 | 2.01 |
| 20 | 29 | | −1.2 | 1.44 | 0.05 |
| | Average time = 30.2 | | | | $\chi^2$ = 16.85 |

p-value is > $\chi^2$, so data is reproducible

all the readings were reproducible at p-value (30.144), 5% level of significance: it has clearly demonstrated that the 60º angle has shorter operative time followed by 30 and then 90º, and the angle 60º followed by 30º were more reproducible than 90º. This is shown in Graph 2 (Figs 3 and 4).

*Third:* Tables 3A to D showed readings of timing taken for ureteroureteral anastomosis in the swine at different manipulation angles which were validated by $\chi^2$ test and average obtained (Fig. 5). The average timing in seconds for 30,

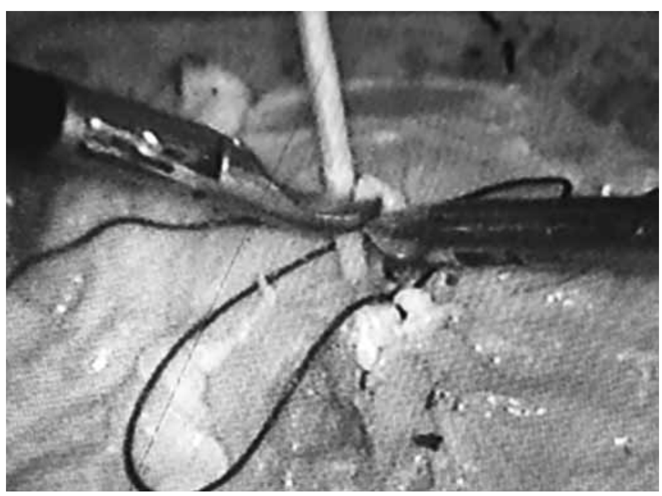


**Fig. 2:** Tying a knot around a fixed distance to ensure the manipulation angle is maintained

**Table 2D:** Average timing of renal vessels clipping

| Manipulation angles in degrees | 30 | 60 | 90 |
|---|---|---|---|
| Mean timing in seconds | 16.00 | 11.10 | 30.20 |
| $\chi^2$ | 9.56 | 11.65 | 16.85 |

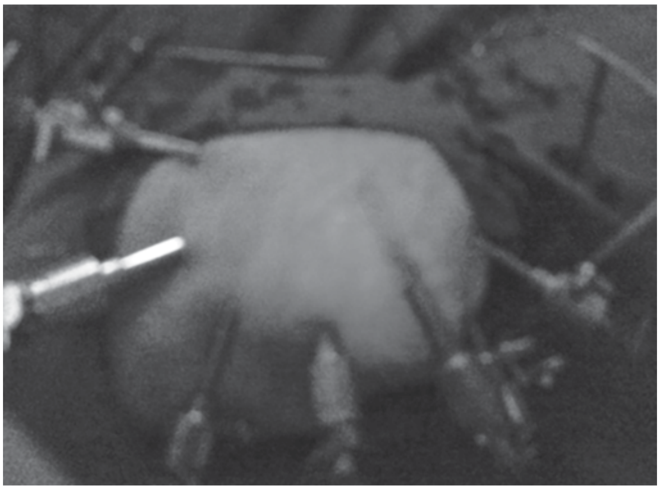


**Fig. 3:** The ports positioning for the upper tract tasks on the swine with illumination

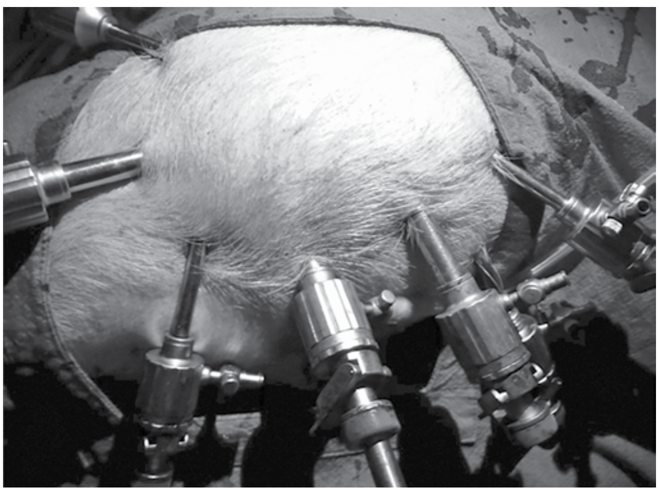
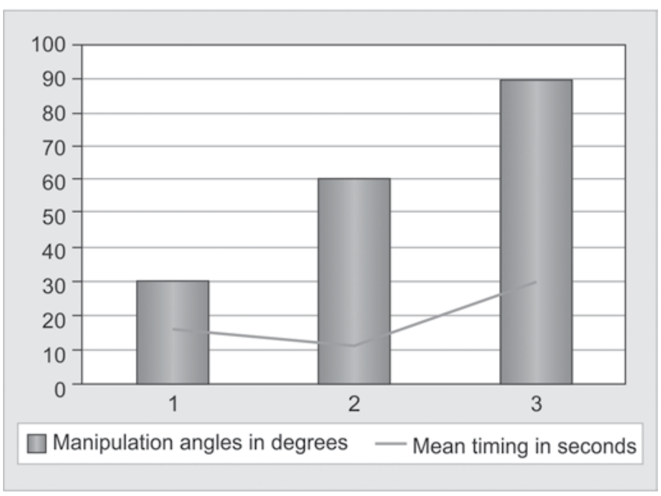


**Fig. 4:** The ports positioning for the upper tract tasks on the swine




**Graph 2:** Timing of renal vessels clipping

**Table 3A:** Timing of ligation of ureteroureteric anastomosis with 30º manipulation angle

| *Sl. no.* | Observed (*O*) | *Expected (E)* | *O-E* | *(O-E)²* | *(O-E)²/E* |
|---|---|---|---|---|---|
| 1 | 387 | 381.65 | 5.35 | 28.62 | 0.075 |
| 2 | 377 | | −4.65 | 21.62 | 0.057 |
| 3 | 397 | | 15.35 | 235.62 | 0.62 |
| 4 | 372 | | −9.65 | 93.12 | 0.24 |
| 5 | 310 | | −28.35 | 803.72 | 2.11 |
| 6 | 368 | | −13.65 | 186.32 | 0.49 |
| 7 | 389 | | 7.35 | 54.02 | 0.14 |
| 8 | 398 | | 16.35 | 267.32 | 0.70 |
| 9 | 387 | | 5.35 | 28.62 | 0.07 |
| 10 | 401 | | 19.35 | 374.42 | 0.98 |
| 11 | 390 | | 8.35 | 69.72 | 0.18 |
| 12 | 403 | | 21.35 | 455.82 | 1.19 |
| 13 | 402 | | 20.35 | 414.12 | 1.09 |
| 14 | 304 | | −77.65 | 6029.52 | 15.80 |
| 15 | 391 | | 9.35 | 87.42 | 0.23 |
| 16 | 398 | | 16.35 | 267.32 | 0.70 |
| 17 | 393 | | 5.35 | 128.82 | 0.34 |
| 18 | 395 | | 19.35 | 178.22 | 0.47 |
| 19 | 381 | | −0.65 | 0.42 | 0.00 |
| 20 | 390 | | 8.35 | 69.72 | 0.18 |
| | Average time = 381.65 | | | | $\chi^2$ = 25.66 |

p-value (30.144) is > $\chi^2$, so data are reproducible

**Table 3B:** Ureteroureteric anastamosis with manipulation angle 60º

| *Sl. no.* | *Observed time in second (O)* | *Expected time (E)* | *(O-E)* | *(O-E)²* | *(O-E)²/E* |
|---|---|---|---|---|---|
| 1 | 320 | 306.6 seconds | 13.4 | 179.56 | 0.59 |
| 2 | 310 | | 3.4 | 11.56 | 0.034 |
| 3 | 315 | | 8.4 | 70.56 | 0.23 |
| 4 | 298 | | −8.6 | 73.96 | 0.24 |
| 5 | 296 | | −10.6 | 112.36 | 0.37 |
| 6 | 306 | | −0.60 | 0.36 | 0.00 |
| 7 | 310 | | 3.4 | 11.56 | 0.038 |
| 8 | 310 | | 3.4 | 11.56 | 0.038 |
| 9 | 306 | | −0.6 | 0.36 | 0.00 |
| 10 | 302 | | −4.6 | 21.16 | 0.070 |
| 11 | 315 | | 8.40 | 70.56 | 0.23 |
| 12 | 299 | | −7.6 | 57.76 | 0.19 |
| 13 | 307 | | 0.40 | 0.16 | 0.00 |
| 14 | 309 | | 2.4 | 5.76 | 0.019 |
| 15 | 309 | | 2.4 | 5.76 | 0.019 |
| 16 | 309 | | 2.4 | 5.76 | 0.019 |
| 17 | 307 | | 0.40 | 0.16 | 0.00 |
| 18 | 305 | | −1.60 | 2.56 | 0.0083 |
| 19 | 299 | | −7.6 | 57.76 | 0.1884 |
| 20 | 300 | | −6.6 | 43.56 | 0.1421 |
| | Average time = 306.60 seconds | | | | $\chi^2$ = 2.43 |

p-value (30.144) > $\chi^2$, so data are reproducible

60 and 90º were 381.65, 306.60 and 460.45 respectively. Only readings at 30 and 60º were reproducible at p-value (30.144), 5% level of significance; but the $\chi^2$ of readings at 90 was less than p-value, indicating nonreproducibility. These suggest that the 60º angle has shorter operative time then the 30º and also demonstrated that the more difficult, a laparoscopic task, is more likely it become nonreproducible at an angle of 90º and above, probably due to fatique from high elevation angle and shoulder over stretching due to poor ergonomics.[41] This is shown in Graph 3.

**Table 3C:** Timing for ureteroureteral anastomosis at manipulation angle 90º

| *Sl. no.* | *Observed time in sec. (O)* | *Expected time (E)* | *O-E* | *(O-E)²* | *(O-E)²/E* |
|---|---|---|---|---|---|
| 1 | 445 | 460.45 | 15.45 | 238.70 | 0.52 |
| 2 | 470 | | 9.55 | 91.20 | 020 |
| 3 | 468 | | 7.85 | 57.00 | 0.13 |
| 4 | 492 | | 31.55 | 995.41 | 2.16 |
| 5 | 415 | | –45.45 | 2065.70 | 4.49 |
| 6 | 462 | | 1.55 | 2.40 | 0.01 |
| 7 | 447 | | – 13.55 | 180.90 | 0.39 |
| 8 | 480 | | 19.55 | 382.20 | 0.83 |
| 9 | 479 | | 18.55 | 344.10 | 0.75 |
| 10 | 412 | | 48.55 | 2347.40 | 5.10 |
| 11 | 482 | | 21.55 | 464.40 | 1.01 |
| 12 | 499 | | 38.55 | 1486.10 | 3.23 |
| 13 | 433 | | 27.55 | 753.50 | 1.64 |
| 14 | 483 | | 22.55 | 508.50 | 1.10 |
| 15 | 490 | | 29.55 | 873.20 | 1.90 |
| 16 | 495 | | 34.55 | 1197.70 | 2.59 |
| 17 | 432 | | –28.45 | 809.40 | 1.76 |
| 18 | 453 | | –7.45 | 55.50 | 0.12 |
| 19 | 469 | | 8.55 | 73.10 | 0.16 |
| 20 | 413 | | –47.45 | 2251.50 | 4.89 |
| | Average time = 460.45 | | | | $\chi^2$ = 32.95 |

p-value (30.144) < $\chi^2$, so data are not reproducible

**Table 3D:** Average timing for ureteroureteral anastomosis

| | | | |
|---|---|---|---|
| Manipulation angles in degree | 30 | 60 | 90 |
| Mean timing in seconds | 381.65 | 306.60 | 460.45 |
| $\chi^2$ | 25.66 | 2.43 | 32.95 |

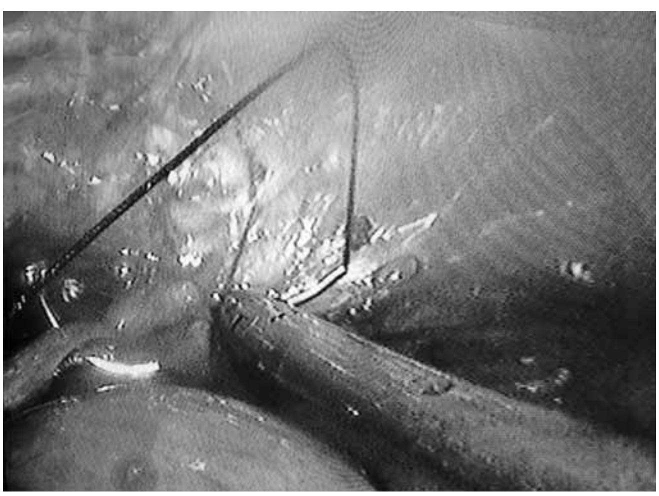
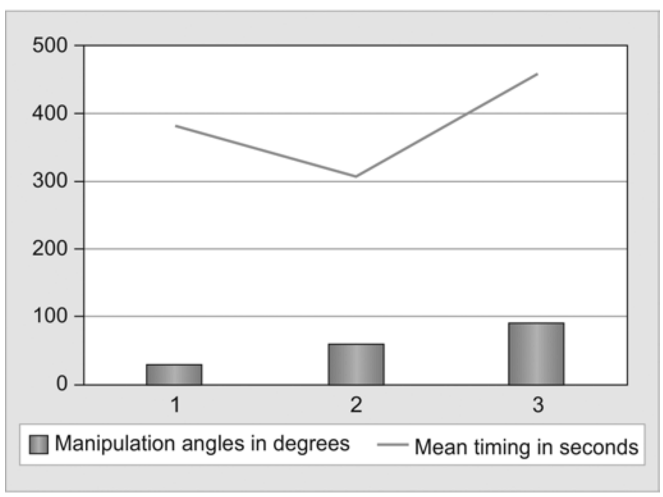


**Fig. 5:** The approximate manipulation angle while knotting in the upper tract in a swine

**Fig. 6:** Arrangement of port's positions for tasks in the pelvis

**Fig. 7:** A picture of ring transfer in the pelvis at 60° manipulation angle




**Graph 3:** Average timing of ureteroureteral anastomosis

**Table 4A:** Timing for ring transfer in pelvis with manipulation angle 30°

| *Sl. no.* | *Observed time in sec. (O)* | *Expected time (E)* | *O-E* | *(O-E)²* | *(O-E)²/E* |
|---|---|---|---|---|---|
| 1 | 27 | 33.2 | 6.2 | 38.44 | 1.16 |
| 2 | 41 | | 7.8 | 60.84 | 1.83 |
| 3 | 35 | | 1.8 | 3.24 | 0.10 |
| 4 | 20 | | −13.2 | 174.24 | 5.25 |
| 5 | 38 | | 4.8 | 23.04 | 0.69 |
| 6 | 62 | | 28.8 | 829.44 | 24.98 |
| 7 | 48 | | 14.8 | 219.04 | 6.60 |
| 8 | 34 | | 0.8 | 0.64 | 0.02 |
| 9 | 48 | | 14.8 | 219.04 | 6.60 |
| 10 | 31 | | −2.2 | 4.84 | 0.15 |
| 11 | 30 | | −3.2 | 10.24 | 0.31 |
| 12 | 27 | | −6.2 | 38.44 | 1.16 |
| 13 | 38 | | 4.8 | 23.04 | 0.69 |
| 14 | 31 | | −2.2 | 4.84 | 0.15 |
| 15 | 39 | | 5.8 | 33.64 | 1.01 |
| 16 | 32 | | 1.2 | 1.44 | 0.04 |
| 17 | 42 | | 8.8 | 77.44 | 2.33 |
| 18 | 35 | | 1.8 | 3.24 | 0.10 |
| 19 | 25 | | −8.2 | 67.24 | 2.03 |
| 20 | 40 | | 6.8 | 46.24 | 1.39 |
| | Average time = 33.2 | | | | $\chi^2$ = 56.57 |

p-value (30.144) < $\chi^2$, so data are not reproducible

**Table 4B:** Time for ring transfer in pelvis with manipulation angle 60º

| *Sl. no.* | *Observed time in sec. (O)* | *Expected time (E)* | *O-E* | *(O-E)²* | *(O-E)²/E* |
|---|---|---|---|---|---|
| 1 | 15 | 20.1 | −5.1 | 26.01 | 1.29 |
| 2 | 19 | | −1.1 | 1.21 | 0.06 |
| 3 | 24 | | 3.9 | 15.21 | 0.76 |
| 4 | 22 | | 1.9 | 3.61 | 0.18 |
| 5 | 22 | | 1.9 | 3.61 | 0.18 |
| 6 | 25 | | 4.9 | 24.01 | 1.20 |
| 7 | 24 | | 3.9 | 15.21 | 0.76 |
| 8 | 22 | | 1.9 | 3.61 | 0.18 |
| 9 | 19 | | −1.1 | 1.21 | 0.06 |
| 10 | 16 | | −4.1 | 16.8 | 0.84 |
| 11 | 17 | | −3.1 | 9.61 | 0.48 |
| 12 | 19 | | −1.1 | 1.21 | 0.06 |
| 13 | 21 | | 0.9 | 0.81 | 0.00 |
| 14 | 17 | | −3.1 | 9.6 | 0.48 |
| 15 | 21 | | 0.9 | 0.81 | 0.00 |
| 16 | 25 | | 4.9 | 24.01 | 1.19 |
| 17 | 20 | | −0.1 | 0.01 | 0.00 |
| 18 | 20 | | −0.1 | 0.01 | 0.00 |
| 19 | 15 | | −5.1 | 26.01 | 1.29 |
| 20 | 19 | | 1.1 | 1.21 | 0.06 |
| | Average time = 20.1 | | | | $\chi^2$ = 8.64 |

p-value (30.144) > $\chi^2$, so data are reproducible

**Table 4C:** Timing for ring transfer in pelvis with manipulation angle 90º

| *Sl. no.* | *Observed time in sec. (O)* | *Expected time (E)* | *O-E* | *(O-E)²* | *(O-E)²/E* |
|---|---|---|---|---|---|
| 1 | 90 | 72.35 | 17.65 | 311.52 | 4.31 |
| 2 | 82 | | 9.65 | 93.12 | 1.29 |
| 3 | 85 | | 12.65 | 160.02 | 2.21 |
| 4 | 75 | | 2.65 | 7.02 | 0.10 |
| 5 | 54 | | 18.35 | 336.72 | 4.65 |
| 6 | 60 | | −12.35 | 152.52 | 2.11 |
| 7 | 96 | | 23.65 | 559.32 | 7.73 |
| 8 | 59 | | −13.35 | 178.22 | 2.46 |
| 9 | 74 | | 1.65 | 2.72 | 0.04 |
| 10 | 49 | | −23.35 | 545.22 | 7.54 |
| 11 | 56 | | −16.35 | 267.32 | 3.70 |
| 12 | 69 | | −3.35 | 11.22 | 1.16 |
| 13 | 86 | | 13.65 | 186.32 | 2.58 |
| 14 | 87 | | 14.65 | 214.62 | 2.97 |
| 15 | 67 | | −535 | 28.62 | 0.40 |
| 16 | 63 | | −9.35 | 87.42 | 1.20 |
| 17 | 68 | | −4.35 | 18.92 | 0.26 |
| 18 | 79 | | 6.65 | 44.22 | 0.61 |
| 19 | 73 | | 0.65 | 0.42 | 0.01 |
| 20 | 74 | | 1.65 | 2.72 | 0.04 |
| | Average time = 72.35 seconds | | | | $\chi^2$ = 44.33 |

p-value (30.144), data are not reproducible

**Table 4D:** Average timing of ring transfer in the pelvis

| Manipulation angle in degrees | 30 | 60 | 90 |
|---|---|---|---|
| Mean timing in seconds | 33.20 | 20.10 | 72.35 |
| $\chi^2$ | 56.57 | 8.64 | 44.33 |

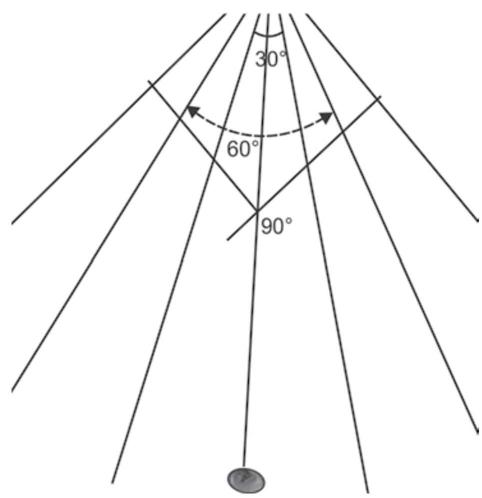
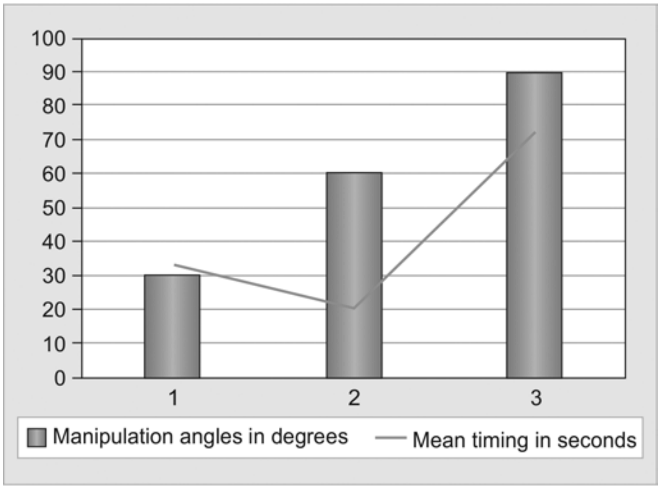



**Fig. 8:** Estimation of manipulation angles determining ports' positions on the dry lab anterior abdominal wall

*Fourth:* Tables 4A to D showed readings of timing taken for ring transfer in the pelvic region of the dummies at different manipulation angles, which were validated by $\chi^2$ test and average obtained (Figs 6 to 9). The average timing in seconds for 30, 60 and 90º were 33.20, 20.10 and 72.35 respectively. Here, only the readings at 60º manipulation angle were reproducible at p-value (30.144), 5% level of significance: which further support any port position that




**Graph 4:** Timing of ring transfer in the pelvis

**Fig. 9:** Instruments and ports at different positions of task performance

**Table 5A:** Time for surgeon's knotting in pelvis with manipulation angle 30º

| Sl. no. | Observed time in sec. (O) | Expected time (E) | O-E | $(O-E)^2$ | $\frac{(O-E)^2}{E}$ |
|---|---|---|---|---|---|
| 1 | 156 | 160.60 | –4.6 | 21.16 | 0.13 |
| 2 | 169 | | 8.4 | 70.56 | 0.44 |
| 3 | 156 | | –4.6 | 21.16 | 0.13 |
| 4 | 162 | | 1.4 | 1.96 | 0.01 |
| 5 | 159 | | –1.6 | 2.56 | 0.02 |
| 6 | 137 | | –23.6 | 556.96 | 3.47 |
| 7 | 159 | | –1.6 | 2.56 | 0.01 |
| 8 | 182 | | 21.4 | 457.96 | 2.85 |
| 9 | 161 | | 0.4 | 0.16 | 0.00 |
| 10 | 139 | | –21.4 | 466.56 | 2.91 |
| 11 | 142 | | –18.6 | 345.96 | 2.15 |
| 12 | 144 | | –16.6 | 275.56 | 1.72 |
| 13 | 184 | | 23.4 | 547.56 | 3.41 |
| 14 | 162 | | 1.4 | 1.96 | 0.01 |
| 15 | 182 | | 21.4 | 457.96 | 2.85 |
| 16 | 161 | | –0.4 | 0.16 | 0.00 |
| 17 | 156 | | –4.6 | 21.16 | 0.13 |
| 18 | 182 | | 21.4 | 457.96 | 2.85 |
| 19 | 156 | | –4.6 | 21.16 | 0.13 |
| 20 | 163 | | 2.4 | 5.76 | 0.04 |
| | Average time = 160.60 | | | | $\chi^2$ = 23.26 |

p-value > $\chi^2$, data are reproducible

**Table 5B:** Time for surgeon's knotting in pelvis with manipulation angle 60º

| Sl. no. | Observed time in sec. (O) | Expected time (E) | O-E | $(O-E)^2$ | $\frac{(O-E)^2}{E}$ |
|---|---|---|---|---|---|
| 1 | 120 | 116.50 | 3.5 | 12.25 | 0.11 |
| 2 | 120 | | 3.5 | 12.25 | 0.11 |
| 3 | 121 | | 4.5 | 20.25 | 0.17 |
| 4 | 118 | | 1.5 | 2.25 | 0.48 |
| 5 | 109 | | –7.5 | 56.25 | 0.02 |
| 6 | 115 | | –1.5 | 2.25 | 1.05 |
| 7 | 120 | | 3.5 | 12.25 | 0.02 |
| 8 | 115 | | –1.5 | 2.25 | 0.17 |
| 9 | 121 | | 4.5 | 20.25 | 0.02 |
| 10 | 118 | | 1.5 | 2.25 | 0.48 |
| 11 | 109 | | –7.5 | 56.25 | 0.17 |
| 12 | 112 | | –4.5 | 20.25 | 0.05 |
| 13 | 111 | | –5.5 | 30.25 | 0.26 |
| 14 | 119 | | 2.5 | 6.25 | 0.05 |
| 15 | 114 | | –1.5 | 2.25 | 0.02 |
| 16 | 118 | | 1.5 | 2.25 | 0.02 |
| 17 | 125 | | 8.5 | 72.25 | 0.62 |
| 18 | 115 | | –1.5 | 2.25 | 0.02 |
| 19 | 119 | | 2.5 | 6.25 | 0.05 |
| 20 | 121 | | 4.5 | 20.25 | 0.17 |
| | Average time = 116.50 | | | | $\chi^2$ = 4.08 |

p-value (30.144) > $\chi^2$, so data are reproducible

**Table 5C:** Time for surgeon's knotting in pelvis with manipulation angle 90º

| Sl. no. | Observed time in sec (O) | Expected time (E) | O-E | $(O-E)^2$ | $\frac{(O-E)^2}{E}$ |
|---|---|---|---|---|---|
| 1 | 190 | 210.55 | –20.55 | 422.30 | 2.01 |
| 2 | 220 | | 9.45 | 89.30 | 0.42 |
| 3 | 197 | | –13.55 | 183.60 | 0.87 |
| 4 | 182 | | –28.55 | 815.10 | 3.87 |
| 5 | 182 | | –28.55 | 815.10 | 3.87 |
| 6 | 172 | | –38.55 | 1486.10 | 7.06 |
| 7 | 183 | | –27.55 | 759.00 | 3.60 |
| 8 | 224 | | 13.45 | 180.90 | 0.86 |
| 9 | 221 | | 10.45 | 109.20 | 0.52 |
| 10 | 235 | | 25.55 | 652.80 | 3.10 |
| 11 | 272 | | 61.45 | 3776.0 | 17.93 |
| 12 | 208 | | –13.55 | 183.60 | 0.87 |
| 13 | 223 | | 12.45 | 155.00 | 0.74 |
| 14 | 204 | | –6.55 | 42.90 | 0.20 |
| 15 | 207 | | –3.55 | 12.60 | 0.056 |
| 16 | 219 | | 8.45 | 71.40 | 0.34 |
| 17 | 226 | | 15.45 | 238.70 | 1.13 |
| 18 | 240 | | 29.45 | 867.30 | 4.12 |
| 19 | 234 | | 23.45 | 549.90 | 2.61 |
| 20 | 224 | | 13.45 | 180.90 | 0.86 |
| | Average time = 210.55 | | | | $\chi^2$ = 59.17 |

p-value (30.144) < $\chi^2$, data are nonreproducible

**Table 5D:** Average timing for surgeon's knotting in the pelvis

| Manipulation angle in degrees | 30 | 60 | 90 |
|---|---|---|---|
| Mean timing in seconds | 160.60 | 116.50 | 210.55 |
| $\chi^2$ | 23.26 | 4.08 | 59.17 |

will provide working angle of 60º as the ideal. This is shown in Graph 4.

*Fifth:* Tables 5A to D showed readings of timing of surgeon's knotting in the pelvic cavity of dummies at different manipulation angles which were validated by $\chi^2$ tests and average obtained (Figs 9 and 10). The average timing in seconds for 30, 60 and 90º were 160.60, 116.50 and 210.55 respectively. Despite the facts that, the first two readings were reproducible at p-value (30.144), 5% level of significance: it has clearly demonstrated that the 60º angle has shorter operative time than that of 30º. The readings of 90º angle were nonreproducible for surgeons knotting in the pelvis indicating increased difficulties and time consumption when ports are positioned in such a way that will give working angle of 90º and above (Figs 10 and 11).

This is shown in Graph 5.

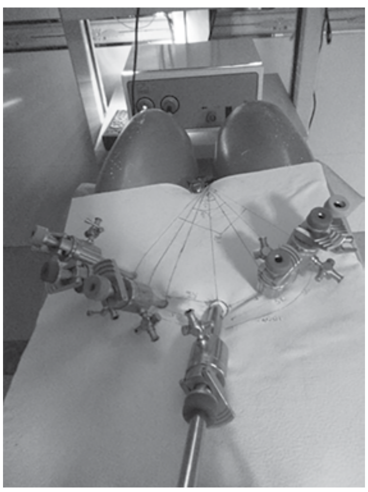
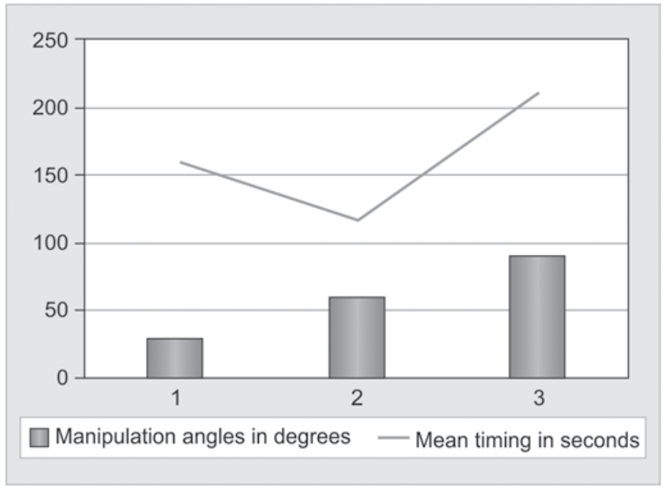
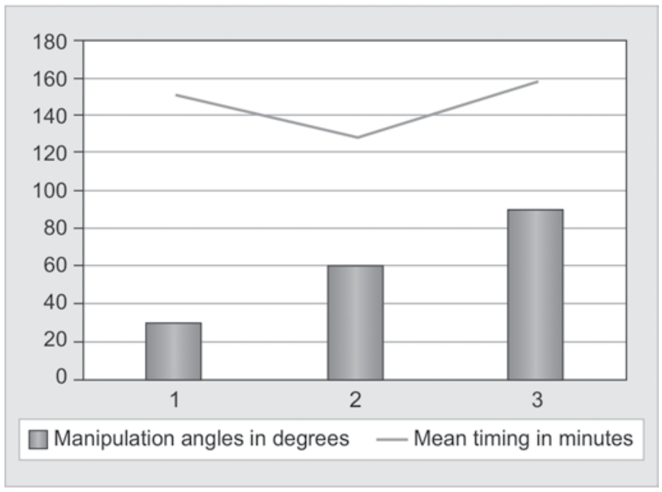


**Fig. 10:** Description of ports' sites on the anterior abdominal wall

**Fig. 11:** Performing a task with 90° manipulation angle in the pelvis




**Graph 5:** Average timing of surgeon's knotting in the pelvis




**Graph 6:** Laparoscopic donor nephrectomy

**Table 6A:** Timing of laparoscopic donor nephrectomy with approximate 30º manipulation angle

| Sl. no | Observed (O) | Expected (E) | O-E | $(O\text{-}E)^2$ | $\frac{(O\text{-}E)^2}{E}$ |
|---|---|---|---|---|---|
| 1 | 157 | 151.50 | 5.5 | 30.25 | 0.20 |
| 2 | 157 | | 5.5 | 30.25 | 0.20 |
| 3 | 159 | | 7.5 | 56.25 | 0.37 |
| 4 | 157 | | 5.5 | 30.25 | 0.20 |
| 5 | 132 | | –19.5 | 380.25 | 2.51 |
| 6 | 147 | | –4.5 | 20.25 | 0.13 |
| Mean | 151.50 | | | | $\chi^2 = 3.61$ |

p-value > (11.070) $\chi^2$, so data are reproducible

**Table 6B:** Timing of laparoscopic donor nephrectomy with approximate 60º manipulation angle

| Sl. no. | Observed (O) | Expected (E) | O-E | $(O\text{-}E)^2$ | $\frac{(O\text{-}E)^2}{E}$ |
|---|---|---|---|---|---|
| 1 | 122 | 128.50 | –6.5 | 42.25 | 0.33 |
| 2 | 121 | | –7.5 | 56.25 | 0.44 |
| 3 | 136 | | 7.5 | 56.25 | 0.44 |
| 4 | 137 | | 8.5 | 72.25 | 0.56 |
| 5 | 188 | | –10.5 | 110.25 | 0.86 |
| 6 | 137 | | 8.5 | 72.25 | 0.56 |
| Mean in minutes | 128.50 | | | | $\chi^2 = 3.19$ |

p-value (11.070) > $\chi^2$, so data are reproducible

*Sixth:* Tables 6A to D showed readings of timing taken for laparoscopic donor nephrectomy and manipulation angles were approximated nearest to 30, 60 and 90º. The readings obtained in minutes were validated by $\chi^2$ tests and average obtained. The averages were 151.50, 128.50 and 158.83 respectively. Although, all the readings were reproducible at p-value (11.070), 5% level of significance: it has clearly demonstrated that the 60º angle has shorter operative time followed by 30º and then 90º, and the angle 60º followed by 30º were more reproducible than 90º. This is shown in Graph 6 (Figs 12 to 19).

**Table 6C:** Approximate manipulation angle of 90º and timing of donor nephrectomy in minutes

| *Sl. no.* | *Observed (O)* | *Expected (E)* | *O-E* | *(O-E)²* | $\frac{(O-E)^2}{E}$ |
|---|---|---|---|---|---|
| 1 | 142 | 158.83 | –16.83 | 283.43 | 1.78 |
| 2 | 186 | | 29.17 | 850.89 | 3.36 |
| 3 | 138 | | –20.83 | 433.89 | 2.73 |
| 4 | 159 | | 0.17 | 0.03 | 0.00 |
| 5 | 148 | | –10.83 | 117.29 | 0.74 |
| 6 | 180 | | 21.17 | 448.17 | 2.82 |
| Mean in minutes | 158.83 | | | | $\chi^2$ = 10.43 |

p-value (11.070) > $\chi^2$, so data are reproducible

**Table 6D:** Average duration of laparoscopic donor nephrectomy in minutes

| Manipulation angles in degree | 30 | 60 | 90 |
|---|---|---|---|
| Mean timing in minutes | 151.50 | 128.50 | 158 |
| $\chi^2$ | 3.61 | 3.19 | 10.43 |

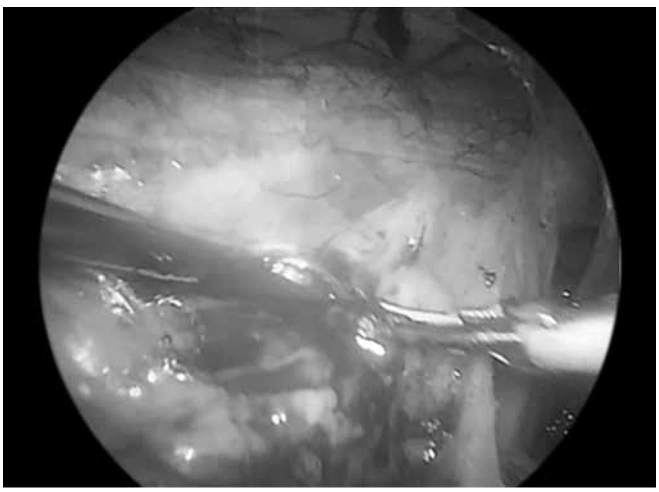


**Fig. 12:** The working angle at one of the ports' positions in a donor nephrectomy

**Fig. 13:** Ports' positions for left laparoscopic donor nephrectomy

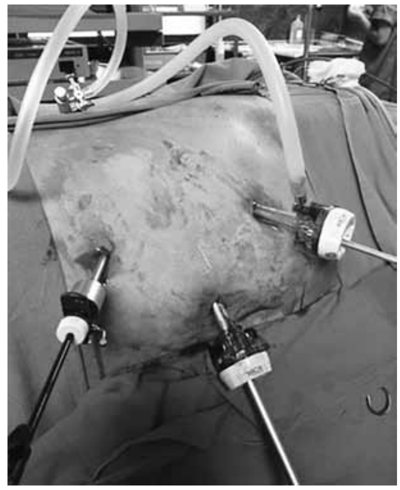


**Fig. 14:** Ports' positions


**Fig. 15:** Sites of ports' positions after left donor nephrectomy

**Fig. 16:** Picture of manipulation angle

**Fig. 17:** Ports' positions

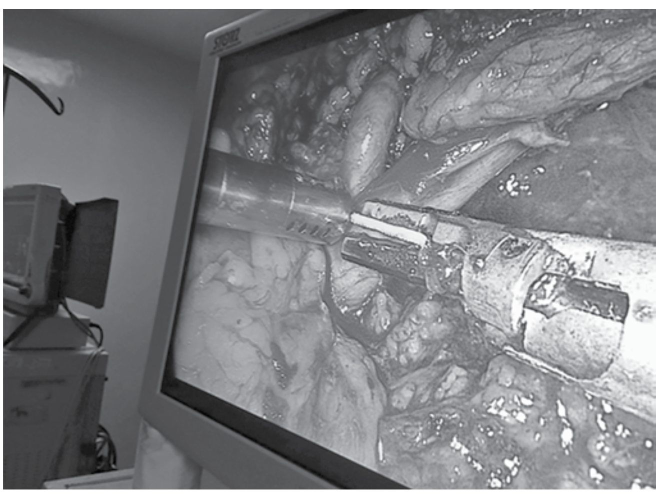


**Fig. 18:** Manipulation angle at the hilum (crucial target of dissection)

*Final:* From all the discussions above, the average timing of all laparoscopic tasks were shorter with 60º manipulation and all were reproducible irrespective of the difficulty of the tasks then followed by 30º. The 90º angle has the longest operative time and, in some cases, nonreproducible, indication the closer the manipulation angle is to the 90º and above, the more the likely to take longer operative time and

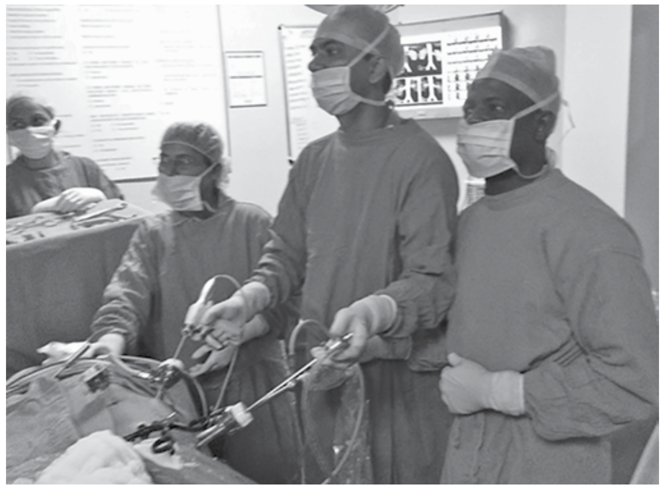


**Fig. 19:** Laparoscopic surgical team of the investigator

the higher it approaches nonreproducibility due to fatigue from increased elevation angle and shoulder overstretching. This is in keeping with the Baseball Diamond concepts of port positioning.

## CONCLUSION

There is no 'ideal port position in urological laparoscopic procedures based on anatomical landmarks, but the closer the ports' positions are to make a manipulation angle of 60º (Baseball Diamond), the closer to ideal it will be.

## RECOMMENDATIONS

More work is to be done on the newly emerging laparoscopic urology particularly in the developing world.

## REFERENCES


1. Supe AN, Kulkarni GV, Supe PA. Ergonomics in laparoscopic surgery. J Min Access Surg 2010;6:31-36.
2. Karthik S, Augustine AJ, Shibumon MM, Pai MV. Analysis of laparoscopic port site complications: a descriptive study. J Min Access Surg 2013;9:59-64.
3. Greberg CF, Gettman MT. Instrumentation for natural orifice transluminal endoscopic surgery and laparoendoscopic single-site surgery. Ind J Urol 2010;26:385-388.
4. Gupta NP, Gautam G. Laparoscopic nephrectomy for benign non-functioning kidneys. J Min Access Surg 2005;149-154.
5. Maurya K, Sivanandam SE, Sukumar S, Bhat S, Kumar G, Nair B. Concomitant laparoscopic urological procedures: does it contribute to morbidity? J Min Access Surg 2009;5:67-71.
6. World Laparoscopy Hospital. Cyberciti, DLF Phase II, NCR Delhi, Gurgaon, 122 002, India. Port position in Laparoscopy.
7. Gupta N, Raina P, Kumar A. Laparoscopic donor nephrectomy. J Min Access Surg 2005;155-164.
8. McDougall EM, Finley D, Clayman RV, et al. Basic urologic laparoscopy: a standardized guideline for training programs. Am Urol Assoc Educ Res 2005;20-25.
9. Veenstra GM, Fossion LMCL, de Laet K, Luijten AAPM. Synchronous laparoscopic radical nephrectomy left and contralateral right hemicolectomy during the same endoscopic procedure. J Laparoendosc Adv Surg Tech 2004.

10. Chung BI, Liao JC. Laparoscopic radical nephrectomy in a pelvic ectopic kidney: keys to success. JSLS 2010;14:126-129.
11. Ganpule AP, Sharma R, Thimmegawda M, Veeramani M, Desai MR. Laparoscopic radical nephrectomy versus open radical nephrectomy in T1-T3 renal tumours: an outcome analysis. Ind J Urol 2008;24:39-43.
12. Rais-Bahrami S, Waingankar N, Richstone L. Upper tract urologic laparoendoscopic single site surgery. Ind J Urol 2012;28:60-64.
13. Kopp RP, Silbestin JL, Derweesh I. Laparoendoscopic single site radical nephrectomy with renal vein thrombectomy: initial report. BMC Urology 2010;8:10.
14. Raman JD, Cadeddu JA. Single access laparoscopic nephrectomy. Ind J Urol 2008;24:457-460.
15. Greberg CF, Gettman MT. Instrumentation for natural orifice transluminal endoscopic surgery and laparoendoscopic single site surgery. Ind J Urol 2010;26:385-388.
16. Thiel DD. Navigating the difficult robotic assisted pyeloplasty. ISRN Urol 2012;2:34.
17. Singh O, Gupta SS, Hastir A, Arvind NK. Laparoscopic transperitoneal pyelo-pyelostomy and ureteroureterostomy of retrocaval ureter: report of two cases and review of the literature. J Min Access Surg 2010;6:53-55.
18. Faddegon S, Tan YK, Olweny EO, Park SK, Sara L. Best BS, Cadeddu JA. Laparoendoscopic single-site (LESS) pyeloplasty for horseshoe ureteropelvic junction obstruction. JSLS 2012; 16:151-154.
19. Bansal P, Gupta A, Mongha R, Narayan S, Kundu AK, Chakraborty SC, et al. Laparoscopic versus open pyeloplasty: comparison of the two surgical approaches—a single centre experience of three years. J Min Access Surg 2008;3:76-79.
20. Mellon MJ, Sethi A, Sundaram CP. Laparoscopic adrenalectomy: surgical techniques. Ind J Urol 2008;24:583-589.
21. Kumar S, Bera MK, Vijay MK, Dutt A, Tiwari P, Kundu AK. Laparoscopic adrenalectomy: a single center experience. J Min Access Surg 2010;6:100-105.
22. Dalvi AN, Thapar PM, Kumar KV, Kamble RS, Rege SA, Deshpande AA, Shah NS, Menon PS. Laparoscopic adrenalectomy: gaining experience by graded approach. J Min Access Surg 2006;2:59-66.
23. Sasaki, et al. Laparoscopic single site adrenalectomy: initial results of cosmetic satisfaction and the potential for postoperative pain reduction. BMC Urology 2013;13:21.
24. Nagraj HK, Kishore TA, Nagalakshmi S. Transperitoneal laparoscopic approach for retrocaval ureter. J Min Access Surg 2006;2:81-82.
25. Agrawal V, Bajaj J, Acharya H, Chanchalani R, Raina VK, Sharma D. Laparoscopic management of pediatric renal and ureteric stone. JP Urol 2013;9:230-233.
26. Ahlawat RK, Gaulam G. Suprapubic transvesical single-port technique for control of lower end of ureter during laparoscopic nephroureterectomy for upper tract transitional cell carcinoma. Ind J Urol 2011;27:190-195.
27. Cestari A, Buffi NM, Scapaticci E, et al. Simplifying patient positioning and port placement during robotic assisted laparoscopic prostatectomy. European Urology 2010;57:530-533.
28. Ashis C, Adnan Q, Aziz A, Edward MD. Optimal port placement during laparoscopic radical prostatectomy. Can J Urol 2012; 19:6142-6146.
29. Columbo JR, Santos B, Hafron J, Gianduzzo T, Haber GP, Kaouk JH. Robotic assisted radical prostatectomy: surgical techniques. Int Braz J Urol 2007;33:803-809.
30. Pow-Sang JM, Velasquez J, Myers MD, Rodriguez AR, Kang LC. Pure laparoscopic and robotic-assisted laparoscopic radical prostatectomy in the management of prostate cancer. Cancer Control 2007;14:250-257.
31. Gerullis H, Kuemniel C, Popken G. Laparoscopic cystectomy with extracorporeal-assisted urinary diversion: experience with 34 patients. European Urology 2007;51:193-198.
32. Cansino JR, Cisneros J, Aloso S, et al. Laparoscopic radical cystectomy: initial series and analysis of result. European Urology Suppl 2006;5:956-961.
33. Vordos D, Hoznek A, Gettman M, Abbon CC. Laparoscopic cystectomy: evolution of a new technique. EAU Series 2005;3: 147-155.
34. Peterson AC, Lance RS, Ahuja SK. Laparoscopic hand assisted radical cystectomy with ileal conduit urinary diversion. J Urol 2002;168:2103-2105.
35. Chan P. Management options of varicocele. Ind J Urol 2011;27: 65-73.
36. Link BA, Kruska JD, Wong C, Kropp BP. Two trocar laparoscopic varicocelectomy: approach and outcomes. JSLS 2006;10: 151-154.
37. Ivovic J. Laparoscopic surgery for varicocele in subfertile men. European Urology Suppl 2009;8:626-627.
38. Capolicchio JP, El-Sherbiny M, Brzezinski A, Eassa W, Jednak R. Dye-assisted lymphatic-sparing laparoscopic varicocelectomy. JP Urol 2013;9:33-37.
39. Moreira-Pinto J, Osorio A, Carvalho F, de Castro JR, de Sousa J, Enes C, Reis A, Cidade-Rodrigues J. Varicocelectomy in adolescents: laparoscopic versus open high ligation technique. Afr J Paediatr Surg 2011;8:40-43.
40. Nerli RB, Reddy M, Devraju S, Prabha V, Hiremath MB, Jali S. Laparoscopic mitrafanoff appendicovesicostomy: our experience in children. Ind J Urol 2012;28:28-31.
41. Available at: www.worldlaparoscopyhospital.com/laparoscopic treatment training and research.