Our Experience of the First 70 Cases in General Surgery with the New daVinciXi Surgical System

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Abstract: We report our preliminary experience with the new daVinciXi system in general surgery. Since September 2014 to December 2015 we performed 70 operations in general abdominal surgery, mainly in colorectal, using the new daVinciXi. The new system has been thought to overcome the critical issues of multi -quadrant robotic surgery, as the intraoperative collision of the arms. This is allowed by the working set up with parallel arms movements, differently than the daVinciSi system. Here we describe our experience and propose our new trocars layout according to the new working disposal of the Xi system.

Keywords: Robotic surgery, daVinci Xi, ports placement, colorectal surgery.

1. INTRODUCTION

Robotic surgery is gaining interest in general abdominal surgery [1]: new technological devices, as three dimensional view, endowrist technology™ with seven degrees of freedom of the instruments and motion scaling, assist the surgeons to overcome technical challenges during complex procedures in laparoscopic surgery [2].

The da Vinci surgical system (Intuitive Surgical Inc., Sunnyvale, CA) is the only robotic surgical platform available approved by Food and Drugs administration.

Da Vinci Xi robotic platform is the last generation of surgical systems developed by Intuitive (Intuitive Surgical Inc., Sunnyvale, CA) that has been thought for the multi-quadrant surgery like low rectal resection and nephrouretectomy.

The main improvements related to Vinci Xi system compared to Vinci Si are:

1- The four arms mounted onto an overhead boom architecture can perform a 360 degrees rotation without conditioning by cart position: this allow surgeons to obtain the most adequate devices position in every moment of the procedure, for every size of patient, also moving simultaneously the four arms to upper or lower abdominal field without moving the robotic cart.

2- Robotic arms can be disconnected and re-connected during the surgical procedure in an easier and faster way, so it's possible to change devices type and position quickly, but also to remove not necessary instruments either to disconnect one arm if it hamper the correct movement in a surgical time in witch the device it support is not necessary.

3- The back of every daVinciXi robotic arm is endowed with two switches (upper and lower) that allow to change robotic arms clearance: this mean that the Assistant at the operative table, can change the slope and the external arms disposal during operation to avoid external conflicts between instruments before they happen.

4- Concerning the cart position, we suggest that it has to be located at the opposite side of the disease surgical site for lateral and uneven organs while its position is quite undifferent for upper or lower GI surgical fields. In this way it is also ensured to Anesthesiologist an easy access to the patient.

5- Eight-mm endoscope that can be inserted in every four robotic trocar: this daVinci Xi innovation allow the surgeon to change endoscope position to obtain a better view during the surgical performance without the need of changing robotic cart or arms position.

6- Chance of automatic targeting: after the selection of the anatomic region of the surgical workspace on the Patient Cart helm the endoscope is pointed on target anatomy and by pressing and holding the targeting button the

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boom automatically rotate and orient itself toward the surgical field. This ensures that the system is oriented and aligned to the center of the surgical workspace established during port placement**.** This daVinciXi improvement makes possible to regulate and to choose the adequate anatomical target for each patient and the automatic disposition of the other arms reduce the risk of internal conflicts during operation.

7- The arms of the da Vinci-Xi are smaller and thinner and have a range of motions. Even the instrument shafts are longer that can allow easier movements with less strength.

These new features of da Vinci xi lead to a different way of working.

While with the da Vinci Si, the ports are placed to encircle the target organ, with a circular positions, da Vinci xi is designed to perform a parallel working arms disposal to maximise the work space and to reduce collisions: so all the ports sites should be positioned along a straight line.

The aim of this work is to highlight the differences of the positions of the ports sites for the da Vinci xi surgical platform and consequently the different surgical technique due to the new robotic system.

2. MATERIAL AND METHODS

From September 2014 to November 2015 at the Maggiore Hospital in Novara, Italy we perform a total of 70 procedures of abdominal general surgery with da Vinci Xi: 51 colorectal resections, 5 distal pancreatectomies, 3 subtotal gastrectomies, 3 resections of gastric/duodenal GIST, 1 adrenalectomy, 5 cholecystectomies and 2 anti reflux procedures.

We routinely induce pneumoperitoneum with a Verres needle introduced in the left hypochondrium (Palmer's point) and first we introduce the Airseal-optic-view trocar (SurgiQuest Inc, Milford, CT, USA) as assistant trocar.

We always follow universal port placement rules:

- Every ports is placed at least 2cm or more from bony prominences,
- All the ports is placed on a straight line at 6-8cmdistance one from the other,
- The initial endoscope port is placed 10-20cm back from the target anatomy, on the oppo-site edge of the surgical workspace boundary.

3. RESULTS

3.1. Upper GI, HPB and Upper Abdomen

We performed a total of 19 procedures, (3 subtotal gastrectomies, 2 antirefluxprocedures, 3 resections of gastric/duodenal GIST, 1 distal pancreasectomy spleen preserving, 4 spleno-pancreatectomies, 1 adrenal-ectomy and 5 cholecystectomies.

For the upper GI and HPB procedures all the ports should be positioned along the transversal umbilical line; then it has to be distinguished if the target anatomy is in the upper left or in the upper right abdomen.

For the upper left abdominal surgical procedures the ports has to be placed as follow:

The initial endoscope port (P2) placed in the umbilicus, port 1 (P1) right lateral, 8cm away from port 2. Ports 3 (P3) and 4 (P4) left lateral to port 2, 8cm away from each other. Assistant (A) port right lateral, at least 7cm from port 1 (Figure **1**).

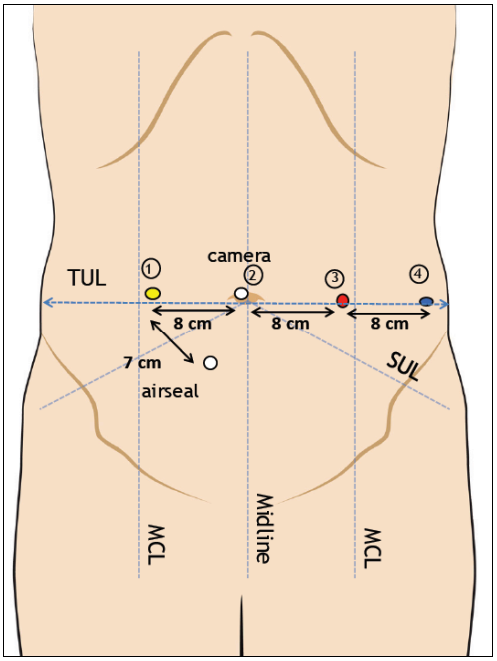

Figure 1: Ports position for left upper abdominal procedures.

For the upper right abdominal surgical procedures the ports have to be placed as follow: the initial endoscope port 3 (P3) in the umbilicus, port 4(P4) left lateral, 8cm away from port 3. Ports 2(P2) and 1(P1) right lateral to port 3, 8cm away from each other. Assistant port (A) left lateral, at least 7cm from port 4 (Figure **2**).

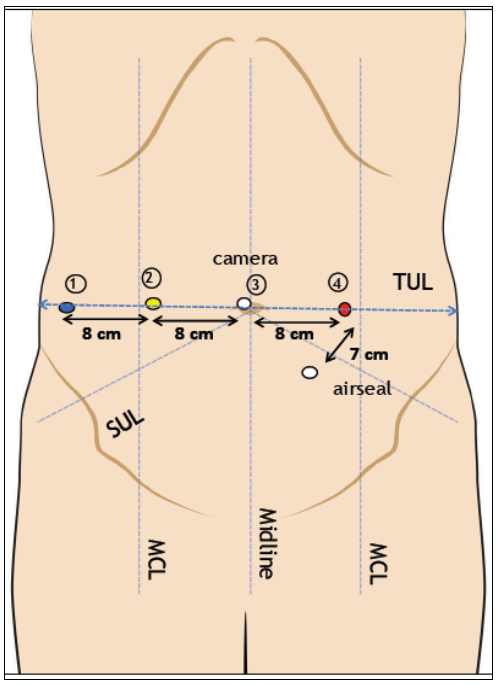

Figure 2: Ports position for Right upper abdominal procedures.

3.2. Right Colectomy

We performed a total of 17 right colectomies. All the procedures has been performed with complete Mesocolon excision (CME) with vessels 's ligation at the origin from superior mesenteric artery (SMA) and superior mesenteric vein and intra-corporeal anastomosis.

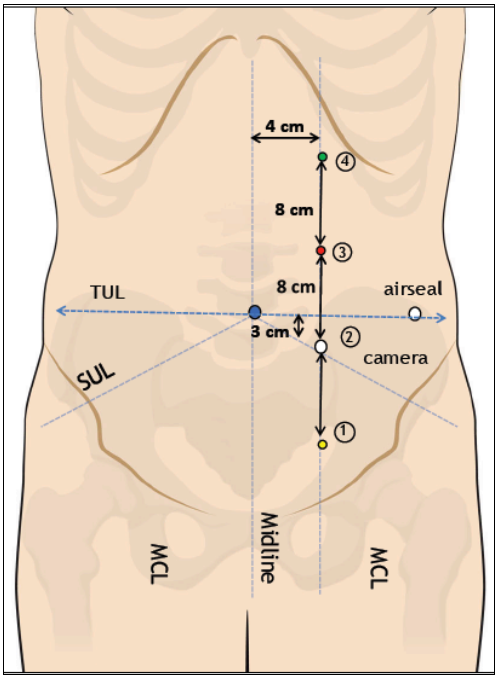

Figure 3: Ports position for Right Colectomy.

For all the procedure on the right abdomen we place all the ports on a straight vertical line parallel and 4cm on the left of the middle line as follow: the first endoscope port (P2) is placed on this line 3cm below the transversal umbilical line. Port 1 (P1) is placed along the vertical line distant 6- 8cm below P2. Ports 3 (P3) and 4 (P4) are placed above to Port 2, 8cm away from each other (Figure **3**).

Airseal trocar is triangulated on P1 and P3, usually on transversal umbilical line and distant at least 2cm of superior iliac spine.

3.3. Left Colectomy and Low Anterior Resection

We performed a total of 21 left colectomy (including three resections of the splenic flexure) and 13 rectal anterior resection (RAR), all done with splenic flexure mobilisation.

Patient is slightly turned on the right in Trendelemburg position. We place the first endoscope port (P 2) 4cm above and 4cm on the right of the umbilicus(main point); then we find a point for P1 on middle line distant at least 8cm from P2. On the line drawn between this two points we place P3 and P4 at the distant of 8cm from each other. Assistant port is triangulated on P3 and P4, on the right (Figure **4**).

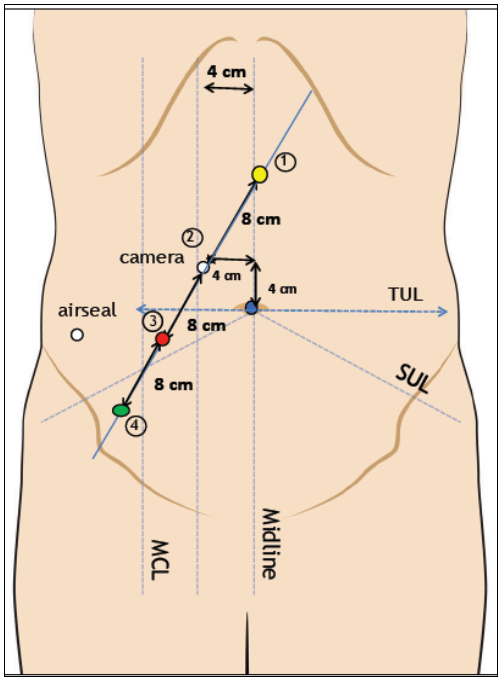

Figure 4: Ports position for Left Colectomy and Low Anterior Resection.

With da Vinci Xi is possible to switch the camera from P2 and P3 during the various phase of the

procedure (endoscope in P3 for vessel ligation and pelvic dissection, endoscope in P2 for splenic flexure mobilisation). Moreover with this particular robotic platform there is no need to place any ports in left iliac fossa.

3.4. Adrenal

We performed one right adrenalectomy for pheochromocytoma.

With the patient in left lateral position at 60 degrees with table flex of 15 degrees.

We placed the first endoscope port (P2) on the midclavear line (MCL) at the level of renal hilum. We drawn a line from P2 to the target anatomy and then on the perpendicular to this line, at least 10cm from the target anatomy, we placed the other trocars: Port 1 (P1) placed 8cm away above P2.

Port 3(P3) and Port 4 (P4) placed 8cm away each other below P2.

This line should be distant at least 10cm from the target anatomy: Port 1 (P1) fall on Axillary Anterior Line (AAL) 8cm above P2 at least at 2cm from the costal margin. Port 3 (P3) and Port 4 (P4) should be positioned distant 8cm from P2 and each other underneath (Figure **5**).

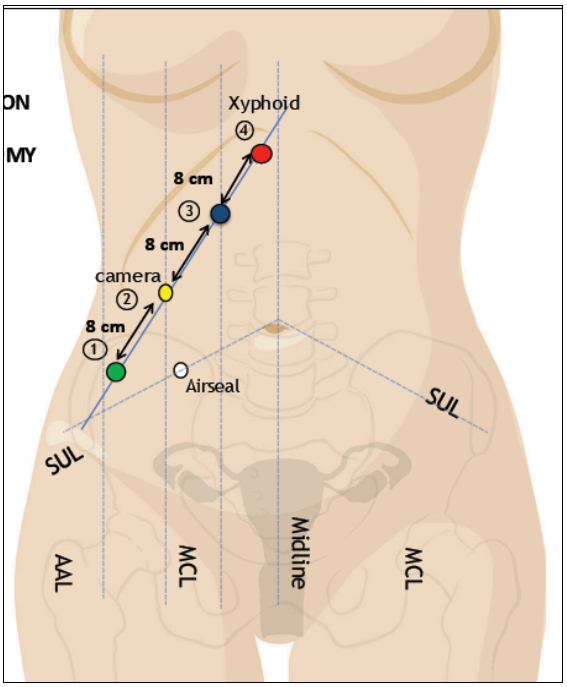

Figure 5: Ports position for Right Adrenalectomy.

4. CLINICAL OUTCOMES

No procedure. - Related death occurred and no conversion was needed. Five patients (3,45%) had a complication:

- Two a grade a pancreatic fistula treated conservatively for distal pancreatectomy,
- Anastomotic leakage in the RAR with splenic flexure mobilization,
- One perforation of a diverticulum above the anastomosis and stomal hernia for left colectomies.

The latter three cases required reoperation by laparotomy.

The mean robotic operative time (operative room occupation) was 380 (Range 180-540)min.

5. DISCUSSION

Robotic surgery is gaining a lot of interest in abdominal general surgery and this lead the research towards the development of new systems more versatile for multiquadrant surgery.

DaVinci Xi is the last generation of the robotic surgical system: this platform has several features that make it more adaptable for procedures with wide surgical field (multiquadrant surgery). The arms reach the surgical field from the boom located above: this allows the arms to work with a greater range of motions. Longer instrument shafts permit the surgeon to reach every abdominal quadrant easier.

These changes, mainly the parallel disposition of working of the arms, entail a different configuration of the positioning of the ports that have to be placed on a straight line, contrary to da Vinci Si.

This do not lead to substantial changes for upper GI procedures and right colectomy, but imposes a radical change for left colectomy and RAR.

In fact, nowadays, for these multiquadrant surgical procedures there is no a ports sites standard configuration as for da Vinci Si.

At the beginning of our experience with da Vinci Xi we followed the Intuitive's recomendations that set all the ports site on a line drawn from the right femoral head (lateral border of Inguinal Triangle) to where the

left mid-clavicular line (MCL) crosses the costal margin, positioning the arm 1 in left hypochondrium.

Our current trocars layout, based on several attempts, is described in Material and methods: The ports are placed on a straight oblique line in the right abdomen, passing through the initial endoscope port site, 4cm above and 4cm on the right of the umbilicus and a point on the midline 8cm away from the camera port site. The trocars are placed one above and two below the scope.

This ports setting determine that the traction instruments is located in the lower right abdomen (arm 4) and not in the left abdomen as in the Kim's or Lagares' configurations for da Vinci Si.

The da Vinci xi surgical platform has an easier installation approaching multiquadrant surgery taking advantage of universal 8mm ports and the possibility of switching the camera port.

We believe that further experiences are needed to better define and to standardise the ports site configuration and surgical technique.

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