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Right Hemicolectomy with Complete Mesocolic Excision Using the Versius Surgical System®: A Step-by-Step Guide

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Rezumat

Hemicolectomia dreaptă cu excizie mezocolică completă folosind Versius Surgical System®

În ultimii 10 ani, aplicarea noilor platforme robotice în chirurgia colorectală s-a extins semnificativ. Au fost lansate noi sisteme care au intrat în panorama chirurgicală, îmbogățind oferta tehnologică. Chirurgia robotică aplicată chirurgiei oncologice colorectale a fost descrisă pe larg. Chirurgia robotică hibridă în cancerul de colon drept a fost raportată anterior. În funcție de localizarea şi extensia locală a unui cancer de colon drept, poate fi necesară o limfadenectomie diferită. Pentru tumorile distale şi local avansate este indicată o excizie completă mezocolică (CME). CME pentru cancerul de colon drept este o procedură mai complexă în comparație cu hemicolectomia dreaptă standard. Prin urmare, CME poate fi efectuată eficient cu ajutorul unui sistem robotizat hibrid, în timpul unei hemicolectomii drepte prin abord minim invaziv, pentru a îmbunătăți acuratețea disecției. Acest studiu prezintă pas-cu-pas o hemicolectomie dreaptă hibridă laparoscopică /robotică, cu CME realizată cu Versius Surgical System®, un sistem robotic chirurgical tele-operat destinat utilizării chirurgiei asistate robotic.

Cuvinte cheie: chirurgie robotică hibridă, CME, CMR Versius

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Abstract

The application of new robotic platforms in colorectal surgery has

increased greatly in the last 10 years. New systems have been released and entered the surgical panorama, broadening the technological offer. Robotic surgery applied to colorectal oncological surgery has been widely described. Hybrid robotic surgery in right sided colonic cancer has been previously reported. According to the site and local extension of a right-sided colon cancer, a different lymphadenectomy could be required. For more distant and locally advanced tumors a complete mesocolic excision (CME) is indicated. CME for right colon cancer is a complex operation compared to standard right hemicolectomy. Therefore a hybrid robotic system may be effectively applied to CME during a minimally-invasive right hemicolectomy to improve the dissection accuracy. Here we report a step-by-step hybrid laparoscopic/robotic right hemicolectomy with CME performed with the Versius Surgical System®, a tele-operated surgical robotic system intended for the use of robotic assisted surgery.

Key words: hybrid robotic surgery, CME, CMR Versius

Introduction

The application of new robotic platforms in colorectal surgery has increased greatly in the last 10 years (1,2). New systems have been released and entered the surgical panorama, broadening the technological offer (3).

One interesting novelty is represented by the possibility of performing a robotic hybrid approach using the robotic system only for those surgical steps requiring greater precision within the surgical field (4).

The Versius Surgical System® is a new tele-operated surgical robotic system intended for the use of robotic assisted surgery (5).

The use of the Versius Surgical System® in colorectal surgery has been reported in few recent series. In particular, its application to right hemicolectomy has been demonstrated to be safe and effective (6,7).

According to the site and local extension of a right-sided colon cancer, a different lymphadenectomy is required. For more distant and locally advanced tumors a complete mesocolic excision (CME) is indicated (8).

It is established that an adequate lymphadenectomy in colorectal oncologic surgery is fundamental both for a therapeutic aim and accurate disease staging, defining the need for adjuvant therapy. The European Society of Medical Oncology (ESMO) and the National Comprehensive Cancer Network (NCCN) guidelines still recommend the removal of a minimum number of 12 regional lymph nodes around the arterial arcades for adequate pathological staging (9). Nevertheless, this number was only partially supported by evidence, as afterwards several authors proposed a different minimum number to be harvested in right colectomy (10).

Hohenberger et al. described the complete mesocolic excision (CME) with central vascular ligation (CVL) as a technique for right colectomy with extended lymphadenectomy along with the embryological anatomical planes. The aim of this procedure is to increase the oncological radicality by providing an extended resection thus including an increased number of harvested lymph nodes in order to improve oncological outcomes (11).

CME for right colon cancer is a complex operation compared to standard right hemicolectomy. It has been fully described and standardized in the current literature (12). When indicated, CME represent one of the most challenging parts of a right hemicolectomy. It is therefore clear that the sharp dissection that robotic surgery allows finds its own ideal application in the CME. It follows that a hybrid robotic system may be simply and effectively applied to CME during a minimally-invasive right hemicolectomy.

Here we report a step by step "How I do it"

hybrid robotic CME with the CMR Versius Surgical System®.

Indications for Right Colectomy with CME

Indications for minimally invasive right colectomy with hybrid approach include right sided colonic tumor, benign polyps not suitable for endoscopic removal, inflammatory bowel disease, right sided diverticular disease. As previously reported, to date, there is no consensus on indications for CME including dissection of gastrocolic Henle's trunk and peripancreatic lymphadenectomy.

Contraindications

There is no absolute contraindication to minimally invasive right colectomy although the feasibly of this approach is usually connected to patients conditions and avoided in case of advanced pregnancy, increased intracranial pressure, severe heart failure, respiratory insufficiency and other conditions that are not suitable for pneumoperitoneum establishment, clinical conditions such as bowel occlusion or extensive intraabdominal adhesions (13).

Preoperative work-up

Endoscopic tattooing is recommended in case of small tumors located at a certain distance from the caecum to define the correct site intraoperatively. Thoracic and abdominal contrast enhanced computerized tomography scan is performed to complete the preoperative disease staging in order to identify metastases and to define T stage of the tumor. Preoperative evaluation includes blood exams, carcinoembryonic antigen test in case for malignant disease, electrocardiogram. Mechanical bowel preparation associated with oral antibiotic prophylaxis are administered before surgery. Intravenous antibiotic prophylaxis is administered according to local hospital policy. Foley catheter is placed in a sterile manner and, after completing the general anesthesia, temporary oro-gastric tube is placed to empty the stomach and prevent aspiration (14).

Surgical Technique

Operative Settings

The patient is placed in supine position with left arm alongside the body. Security devices that guarantee patient's position during the procedure should be placed without interfering with robotic arms' movements on the left side of the patient. The laparoscopic tower is placed on the right side of the patient.

During the laparoscopic steps of the procedure the operating surgeon stands on the left side of the patient as well as the camera holder and the assistant surgeon, while the scrub nurse stands on the right side. During the robotic part of the operation, the robotic units are placed on the left side of the patients with the visual unit in the middle and the assistant surgeon between two robotic units (*Fig. 1*).

The patient is prepared with alcohol or iodine based solution from half chest to the suprapubic area and sterile drapes are placed. All the equipment necessary to perform both the laparoscopic and robotic steps is prepared and connected before starting the procedure in order to avoid any delay during it.

CMR Versius System

Developed by the Cambridge Medical Robotic Limited (CMR Ltd), the Versius system has an open console that allow both standing and sitting according to operator preference, with HD-3D monitor. There is no foot pedal control,

Figure 1.

as all the functions are managed by the joystick controllers, including the camera (*Fig. 2*). One of the main advantages of the system is the small and modular design of the independent carts-mounted robotic arm providing versatility to the system (*Fig. 3*). With an arm's footprint of 38 cm x 38 cm, the system is intended to be a versatile platform that can be moved among operating rooms and stored outside them. According to the procedure, the surgeon can use up to five arms that allows 360 wrist motion thanks to the V-wrist technology with maximum freedom of port placement. The instruments are reusable, 5 mm in size and wristed, allowing 7 degrees of freedom.

Instrumentations

Laparoscopic

Laparoscopic instruments required for right colectomy are:

- 30° 10 or 5 mm scope ± indocyanine green fluorescence technology;
- high definition camera with or without 4K technology ± indocyanine green fluorescence technology;
- high definition monitor with or without 4K technology;
- light source and cable ± indocyanine green fluorescence technology;
- CO2 insufflator;
- high frequency generator;
- advanced energy device;
- one 11 mm, two 12 mm, two 5 mm trocars;
- hook;
- scissors;
- bipolar forceps;
- atraumatic forceps;
- irrigation – suction device;
- clip applier;
- 60 mm articulated linear stapler and cartridges;
- endoscopic bag;
- needle holder;
- wound protector.

Robotic

CMR Versius robotic platform including:

- the open console;
- three robotic arms: the visual unit with robotic optic and camera and two operating units. Instruments of the operating units can be chosen according to surgeon preference, for example a grasper or the bipolar forceps for the left hand and monopolar hook or scissors for the right hand to perform dissection.

Figure 2.

Figure 3.

Step by Step Surgical Technique

Exploratory laparoscopy

Pneumoperitoneum is induced with Verres needle placed in the left subcostal region or with open approach for the first 10 mm port in the left flank, along the middle clavicular line, below the umbilicus (for the scope). The other four ports are placed under vision as follow: 12 mm trocar in the left upper quadrant, along the middle clavicular line, 5 cm below the costal margin, for the right hand of the surgeon; 5 mm trocar in the suprapubic area, in the midline, for the left hand of the surgeon; 5 mm trocar under the left costal margin for the assistant; 12 mm accessory trocar in the left upper quadrant 4 cm lateral to the middle clavicular line, for the assistant during the robotic part of the surgery (*Fig. 4*).

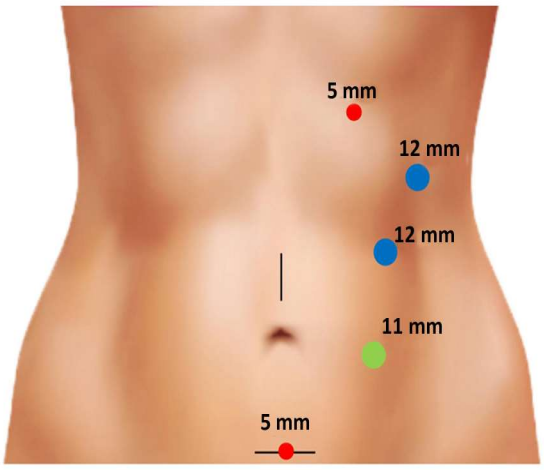

Figure 4.

The procedure starts with exploration of the abdomen in order to confirm tumour site, exclude the presence of peritoneal carcinomatosis and superficial hepatic metastases, and to assess the feasibility of minimally invasive procedure. The patient is placed in mid reverse Trendelemburg position tilted to the left side to move the small bowel in the left iliac fossa exposing the mesentery of the right colon and the route of the superior mesenteric vessels.

Robotic part

Robotic setting

The robotic units are placed on the left side of the patient with the visualization unit in front of the 11 mm port for the scope, one operative unit connected to the monopolar hook inserted into the 12 mm port for the right hand of the surgeon and another unit connected to the bipolar forceps into the 5 mm suprapubic port for the left hand. The height of the base unit is set at the level of patient's abdomen and the flexible part of the units, made of two joints, is shaped like a human arm. As required by the system, the port training is performed for each robotic unit in order to set the pivot point of the instrument in regard to the abdominal wall. The operating surgeon moves to the robotic console. At the beginning of the procedure the 5 mm subcostal port is used by the assistant to grab the transverse colon and the omentum, exposing the axis of the superior mesenteric vein, a fundamental landmark during the complete mesocolic excision. As an alternative, a fourth robotic unit can be used through the 5 mm port and the robotic grasper is maneuvered by the surgeon. The accessory port is used by the assistant for clip applier, suction/irrigation, energy device, endoscopic linear stapler.

Vascular dissection and lymphadenectomy

The left hand of the surgeon retracts the mesocolon of the ascending colon to lift the pedicle of the ileocolic vessels. Using the monopolar hook, the dissection begins at the origin of the ileocolic vessels and the superior mesenteric vein is completely dissected at this level (*Fig. 5*). The ileocolic vein and artery are isolated and divided between clips (*Fig. 6*). The duodenum is identified and gently detached from the mesentery of the right colon (*Fig. 7*). The procedure carries on with lymphadenectomy to perform the complete mesocolic excision following the route of the superior mesenteric vessels upwards. The right colic vessels are divided if present. The

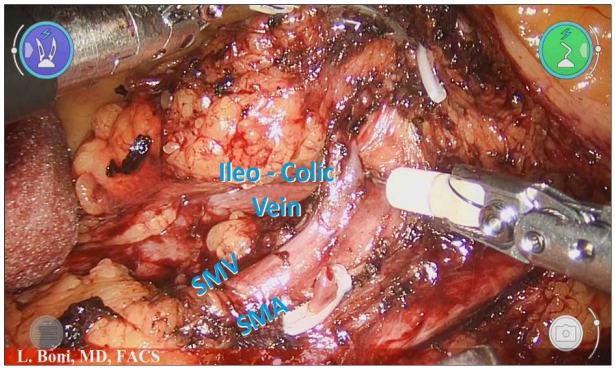

Figure 5.

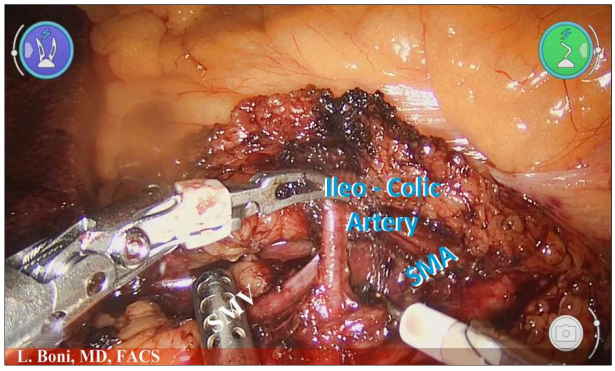

Figure 6.

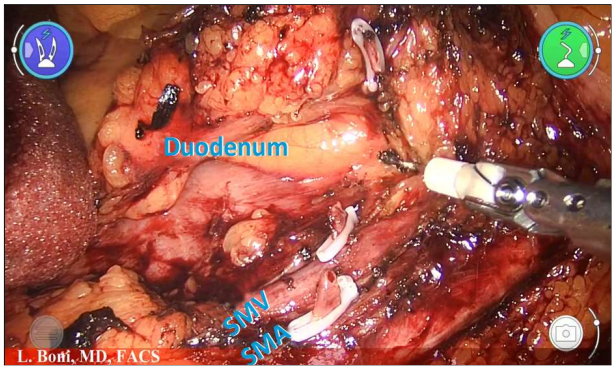

Figure 7.

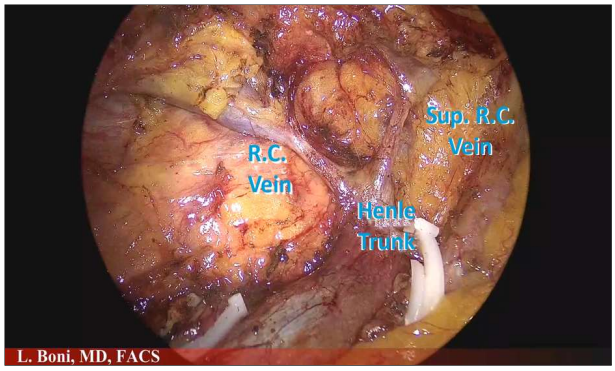

Figure 8.

gastrocolic trunk of Henle's is identified and dissected. According to high anatomical variability at this level, the superior right colic and the right colic veins are dissected and divided between clips, while the right gastroepiploic vein and the anterosuperior pancreaticoduodenal vein are preserved (*Fig. 8*). The procedures moves on with peripancreatic lymphadenectomy. Henle's trunk dissection and peripancreatic lymphadenectomy are the most challenging steps of the procedure, due to the high anatomical variability and the risk of intraoperative bleeding. In case of tumour of the caecum or ascending colon the main trunk of the middle colic artery can be preserved while its right branch is clipped and dived. For tumours of the hepatic flexure or proximal transverse colon, the middle colic artery is dissected, clipped and divided.

Mesocolic excision

At this point the Toldt's fascia, that separates the right mesocolon from retroperitoneum, is dissected. The mobilization in carried out by lifting the mesocolon with the left hand and pushing down the Toldt's fascia covering retroperitoneal structures: second portion of the duodenum, head of the pancreas and right kidney. Usually if dissection is performed along this plane, there is no need to identify right ureter and gonadal vessels. The dissection is extended up to the transverse colon until the mesentery is opened and the liver visualized. At this point the grasper of the assistant is used to retract the omentum while the left hand of the surgeon hold the transverse colon, allowing division of the gastrocolic ligament from medial to later until the right colic flexure is mobilized. The transverse colon is transected using an endoscopic linear stapler inserted by the assistant from the accessory port, choosing the cartridge according to tissue thickness. The mesentery of the ileum is exposed by grasper and divided up to the

bowel wall. The terminal ileum is transected approximately 5-10 cm from the ileocecal valve using the endoscopic linear stapler. The mobilization of the colon from its lateral attachments is completed from the caecum up to the transverse colon. The specimen is inserted into an endobag an placed above the liver. The surgical field is checked for hemostasis. At this point robotic instruments are removed from the ports and the robotic units are moved away from the patients, as the procedure is completed through the standard laparoscopic approach.

Laparoscopic part: anastomosis

Intracorporeal anastomosis

The assistant holds the colon with the grasper, while the terminal ileum is approximated to it in order to perform a side-to-side isoperistaltic anastomosis. At this point indocyanine green fluorescent angiography can be carried out to confirm adequate perfusion of the bowel. The monopolar hook is used to create two enterotomies on the taenia on the colon and on the antimesenteric edge of the ileum. The endoscopic articulated linear stapler is introduced through the 12 mm port, inserted into the small enterotomies and anastomosis is fashioned (*Fig. 9*). The anastomosis is checked for hemostasis and an absorbable cellulose-based hemostatic patch can be inserted into the bowel. The bowel defect is closed with two layer running suture using barbed suture secured with clips at the end.

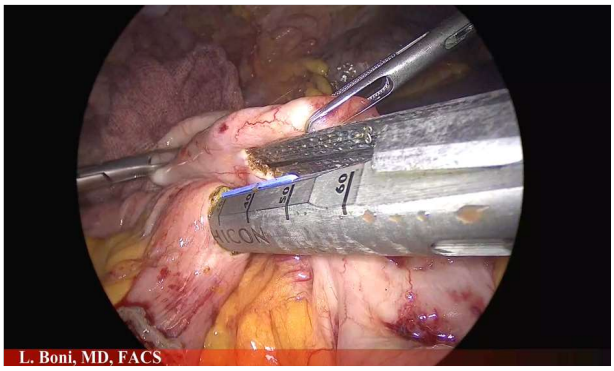

Figure 9.

Absorbable suture can be used as well. The defect of the mesentery is closed through a running suture using a barbed suture. Specimen is extracted through a suprapubic mini-laparotomy Pfannenstiel incision using a wound protector.

Discussion

The application of the CMR Versius Surgical System® to CME during right hemicolectomy is safe and effective. The operative time is comparable to a totally laparoscopic procedure. What robotic surgery adds to the laparoscopic technique is the three-dimensional imaging, the tremor filtration, the higher optical magnification and an independent operator-navigated camera (6). The wristed instruments grant several degrees of freedom and enhance accuracy in the dissection, allowing more precise vascular approaches, extended lymphadenectomy, and a sharper dissection through the anatomical landmarks (3).

In the literature there are several descriptions of robotic CME (15,16). However, a detailed step by step description of a hybrid robotic CME is to date missing. Given the significant increase of the hybrid technique worldwide and its implications in the operative setting, it is essential to provide "how I do it" examples of the feasibility of different hybrid procedures.

The field of operation in colorectal surgery often involves more than one abdominal quadrant, and this may challenge and limit the application of robotic giving the need of re-docking. This also happens during a right hemicolectomy, given the wide surgical field that includes the right pelvic entrance, the right parietocolic gutter, the hepatic flexure and sometimes even the proximal and middle transverse colon (7). Some surgical steps can be easily performed laparoscopically before docking the Versius Surgical System® platform to perform the CME, providing the surgeons with one precise tool to approach an extended and complex lymphadenectomy as

required during a CME (6).

CME might be associated with an increased risk of postoperative complications compared to standard right hemicolectomy such as postoperative ileus, anastomotic fistula, persistent lymphatic leak (17). These complications may derive from some intrinsic characteristics related to CME but also from the accuracy with which CME is performed (18). To this end, using the robotic technique for CME could decrease the incidence of CME-related complications by improving dissection accuracy.

The hand controllers are designed ergonomically to optimize the comfort of the surgeon. The operative console has an open non-immersive structure so that surgeons are able to maintain a direct communication with the operating room team (5).

The Versius docking system is quite simple and user friendly, allowing the surgeon to replicate the conventional setup. This flexibility enables surgeons to effectively transfer the laparoscopic port placements in the robotic setting. Since no specific trocar is needed, the switch from the laparoscopic setting to the robotic one and viceversa is quite simple and fast making. The docking time of the Versius Surgical System® is therefore extremely short, as well as the 'conversion to laparoscopy' time (7).

The possibility of containing the operative time by using the robotic system for the most challenging surgical steps is extremely important in order to implement a robotic program without excessively increasing surgical costs and without reducing the productivity of the operating sessions (2).

A limitation of robotic platforms is the challenge of working in more than one abdominal quadrant. During right hemicolectomy the surgical field changes, moving from a view on the right pelvic entrance, to the right parietocolic gutter and up to the hepatic flexure (7). The related surgical steps can be easily performed laparoscopically before docking the Versius Surgical System® platform to perform the CME, giving the surgeons one precious tool to approach those challenging steps of an extended and complex lymphadenectomy as CME requires (6).

Conclusions

The application of the CMR Versius Surgical System® to CME during right hemicolectomy is safe and effective. Performing a hybrid robotic procedure for right hemicolectomy with CME could decrease the incidence of CME-related complications by improving dissection accuracy.

Conflicts of Interest and Source of Funding

No specific foundings was received for the present work. The authors declare no conflict of interest.

Ethical Statement

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Authors' Contributions

LBa, EC and JC wrote and reviewed the manuscript text. GM and LBo design the study and supervised the content.

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