Focus

The latest robot has arrived at the HUG

Early experiences with the da Vinci Xi Surgical System in digestive surgery

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While there are several patient-related advantages of conventional laparoscopy including shorter hospital stay, decreased postoperative pain, and reduced blood loss1-3, major limitations for this technique do exist, including the cumbersome handling of instruments with limited degree of motion that result in poor ergonomics and sub-optimal visualization. As a result, gold standard laparoscopic procedures are generally of low to moderate complexity, and advanced laparoscopy such as complicated dissections in anatomical areas that are difficult to reach or major reconstructions remain reserved for a limited number of experts with certain rates of conversion to open surgery4, 5.

Surgical robotics have been developed to address the above mentioned technical limitations of conventional laparoscopy and to elevate minimal invasive surgery beyond standard laparoscopy by reaching high precision during complex surgery and potentially improving clinical outcomes. Early developments of surgical robotics trace back to the 1980s when a cooperation between NASA, VPL Inc. in the Silicon Valley (California, USA), and the former Stanford Research Institute resulted in the creation of a robotic device suitable for minimally invasive surgery. The system was further refined and later commercialized by Intuitive Surgical Incorporation (Sunnyvale, CA, USA) as the da Vinci Surgical System®. The da Vinci Standard Surgical System was released to the market in 19996 and contentiously improved with the da Vinci S System in 2006 and the Si System in 2009. The latest version of the da Vinci Surgical System—the da Vinci Xi (Figure 1)—has been marketed since 2014. While all systems of the da Vinci family share common core features including a master-slave configuration with surgical cart, console and vision tower, a three- dimensional vision with up to 10 times magnification, wristed instrumentation with seven degrees of freedom, and distinct software with motion scaling and tremor filtration, the da Vinci Xi comes with some distinct design alterations that represent major changes to previous versions. These design innovations of the novel Xi system include thinner robotic arms with increased range of motion that are mounted on an overhead beam, universal mounts for all instruments and camera, integrated energy housing all applications, a novel camera with chip at the tip technology, standard advanced imaging options (fluorescence imaging), a laser targeting system, and an upgraded user interface to help guide the robotic installation.

Overall, these changes have been designed to facilitate the setup and docking of the robotic system as well as to maximize the surgical field inside the body, thus enabling multi-quadrant surgery in a single robotic set-up without the need to reposition the robotic system.

Our experience with the da Vinci Standard, S, and Si Surgical System

Our experience with all previous da Vinci models dates back to 2006. We were able to demonstrate clinical superiority by a significant decrease of anastomotic leak of the fully “hand-sewn” anastomoses conversion rates, and length of stay of a robotic approach to gastric bypass surgery when compared to standard laparoscopy7, 8 (Figure 2). Particularly, super-obese patients seem to benefit from robotic technology and result in fewer conversion rates and shorter length of stay when compared to laparoscopy9. In addition, we have used the da Vinci single site platform since its release in 2011 for cholecystectomy, which not only appeared to be safe and feasible but also an excellent setup for training residents in robotic surgery10. Also, we applied the robotics to various procedures of the colorectal field with robotic right colonic resections that have been augmented with intra-corporeal robotically-sutured anastomoses. Rectal resections, as an example of multi-quadrant procedure, were performed by us with either a hybrid approach with laparoscopic assistance for the mobilization of the splenic flexure or a complex re-arrangement of the robotic arms with or without re-installation of the cart. Another interesting application of robotics for colorectal surgery was found in robotic trans-anal resection of low-risk rectal cancers and benign indications11 (Figure 3). Furthermore, we selected cases to undergo robotic liver segmentectomies and bisegmentectomies for hepatocellular carcinoma, hepatocellular carcinoma, and cholangiocarcinoma with a slight trend to less minor complications in the robotic group and a decrease in the length of stay compared to open-case matched cases. All resection margins were negative with a comparable distance to the tumor for the robotic and open patients (Unpublished data).
Why Xi for digestive surgery?
Besides our overall positive clinical data for our robotic procedures, we are also aware that robotics have not yet found widespread application in the field of visceral surgery worldwide. While substantial data of clinical superiority for many procedures of the field of digestive surgery is currently still lacking, the robotic system has also been systematically criticized for its cumbersome set-up process, prolonged operating room times, and increased overall costs when compared to alternative surgical approaches.

However, the technological advances of the novel da Vinci Xi Surgical System gives hope that this system might have the capability to address major concerns that were previously raised for robotics in visceral surgery. As such, our motive to start Xi surgery was to use the system to augment our robotic digestive surgery procedures to potentially result in even more clinically and financially efficient procedures.

Our experience with the da Vinci Xi Surgical System
Two da Vinci Xi Surgical Systems were installed in late March 2015 at the University Hospital in Geneva. One of the systems offers a dual console, and the other is a single console setup.

During the first three months since the installation, we applied the da Vinci Xi Surgical System to Roux-en-Y gastric bypass procedures, revisional bariatric surgery converting fundoplication to gastric bypass, colorectal surgery, hepatic resection, and revisional biliary surgery.

Within the first few cases, we were easily able to transition the gastric bypass procedure from a hybrid to a fully robotic approach with single docking (Figure 4). As such, the procedures formerly performed laparoscopically including cholecystectomy, pouch creation, split of the omentum, and measurement of the biliary limb are now performed robotically at our department. The recently released robotic stapler for da Vinci Xi allows a creation of the gastric pouch without de-docking for the introduction of a standard laparoscopic stapler (Figure 5).

All of our Xi low anterior resections, which were formerly performed with either a hybrid approach (laparoscopic mobilization of splenic flexure) or with a re-arrangement of robotic arms with or without repositioning of the surgical cart, were completed with a single robotic docking for all steps of the procedure (Figure 6, 7).
All other procedures remained essentially very similar in their Xi version when compared to their previous methods using older models of the da Vinci system. However, we positively recognized a larger field of surgery that particularly helped during multi-quadrant procedures such as low anterior resections, and overall robotic experience appeared to be more streamlined with the novel features of the Xi system.

An early analysis of our data (unpublished at present) shows a trend towards shorter operating room times for the total robotic Roux-en-Y gastric bypass. None of our cases needed a conversion rate to laparoscopic or open surgery.

Besides our enthusiasm in light of the exciting augmentations for gastric bypass and rectal procedures, we also recognized some areas where the latest version of the da Vinci system could use further improvement: First of all, the dimensions of the surgical cart, which are larger than previous models, pose certain challenges to the docking process when space constraints are present in the operating room. Also, certain instruments including the harmonic scalpel and the single site platform are presently not available. As such, we had to adjust the surgical technique in certain situations, and we had to interrupt our training program on single-site cholecystectomies for younger colleagues.

Conclusions

Our early impression sees the da Vinci Xi Surgical System as a great addition to the da Vinci family, particularly for the field of visceral surgery. Within a short time, complex procedures can be transitioned to fully robotic approaches in multiple abdominal quadrants with streamlined robotic set-up and docking. Ultimately, this should result in shorter operating room times, less stress to the surgical team, and hopefully improved clinical outcomes. Still, it will take time to precisely determine the role of robotics for visceral surgery, and systematic high quality clinical outcomes data need to be created.

References