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Feasibility of Robotic Laparoscopic Surgery: 146 Cases

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Abstract. Theoretically, in laparoscopic surgery, a computer interface in command of a mechanical system (robot) allows the surgeon: (1) to recover a number a number of lost degrees of freedom, thanks to intra-abdominal articulations; (2) to obtain better visual control of instrument manipulation, thanks to three-dimensional vision; (3) to modulate the amplitude of surgical motions by downscaling and stabilization; (4) to work at a distance from the patient. These advances improve the quality of surgical tasks in a perfect ergonomic position. The purpose of this paper is to evaluate the feasibility of utilizing a robot in laparoscopic surgery. The first robot-assisted procedure in humans was performed in March 1997 by our team. One hundred forty-six patients underwent robot-assisted laparoscopic surgery. Between March 1997 and February 2001 a nonconsecutive series was performed of 39 antireflux procedures, 48 cholecystectomies, 28 tubal reanastomoses, 10 gastroplasties for obesity, 3 inguinal hernias, 3 intrarectal procedures, 2 hysterectomies, 2 cardiac procedures, 2 prostactectomies, 2 arteriovenous fistulas, 1 lumbar sympathectomy, 1 appendectomy, 1 laryngeal exploration, 1 varicocele ligation, 1 endometriosis cure, 1 neosalpingostomy, 1 deferent canal. The robot (Da Vinci system, Intuitive Surgical, Mountain View, CA), consists of a console and a cart with three articulated robot arms. The surgeon sits in front of the console, manipulating joysticklike handles while observing the operative field through binoculars that provide a three-dimensional picture. This computer is capable of modulating these data by eliminating physiologic tremor and by downscaling the amplitude of motions by a factor 5 or 3 to one. This study has demonstrated the feasibility of several laparoscopic robotic procedures. There is no morbidity related to the system. Operating time and the hospital stay were within acceptable limits. The system seems most beneficial in intra-abdominal microsurgery or for manipulations in a very small space. Optimized ergonomics and increased mobility of the instrument tips are beneficial in many steps of abdominal surgical procedures.

Laparoscopy is beneficial to the patient, but this type of surgery is more demanding for the surgeon. In laparoscopic surgery, instruments are long and traumatic as they are manipulated through fixed entrance sites, with limited degrees of freedom. Procedures are performed under video guidance from a two-dimensional screen which is not always placed in the working axis [1–3]. All these conditions result in awkward operating positions and impaired dexterity [4–6].

A computer-guided mechanical interface, commonly referred to as a robot, allows for (1) restoration of lost degrees of freedom, thanks to an intra-abdominal articulation of the surgical tools; (2) three-dimensional visualization of the operative field in the same direction as the working direction; (3) modulation of motion amplitude by stabilizing or by downscaling; and (4) remote control surgery (telesurgery). Thanks to these improvements, surgical tasks can be performed with greater accuracy and in a perfect ergonomic position [7].

To place master–slave interface between surgeon and patient will possibly revolutionize surgery in the same way as it did in aviation. The purpose of this report is to evaluate the feasibility of robotic laparoscopic surgery.

Material and Method

With approval from our hospital's ethical committee and after obtaining an informed consent from each patient, 146 patients underwent robot-assisted laparoscopic surgery between March 1997 and February 2001. We performed these procedures in Brussels, Paris, and Mexico City. The first procedures on human

Fig. 1. First clinical prototype in 1997: a three-dimensional picture is obtained with specific glasses. The handles resemble usual surgical tools.

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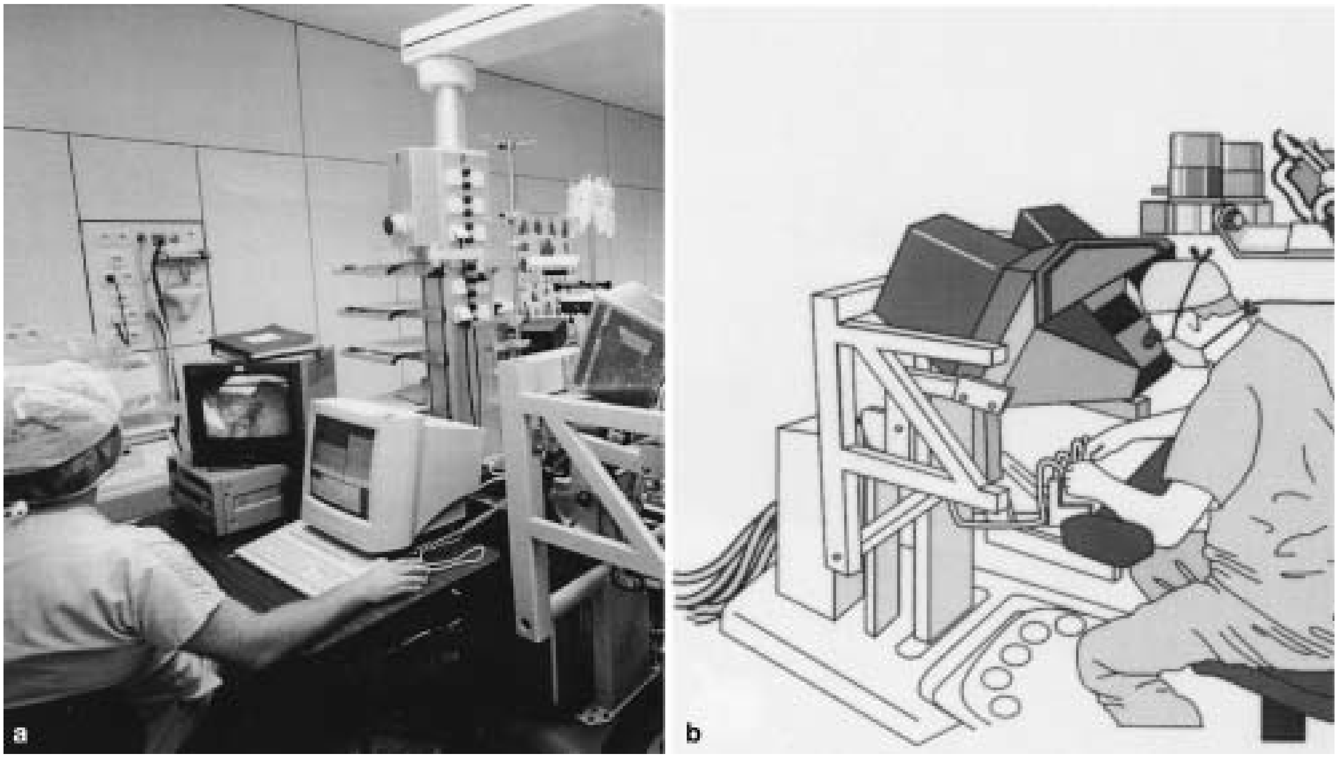


Fig. 2. a,b. The MONA robot in 1998: binocular direct vision without glasses. An engineer must be present at all times.

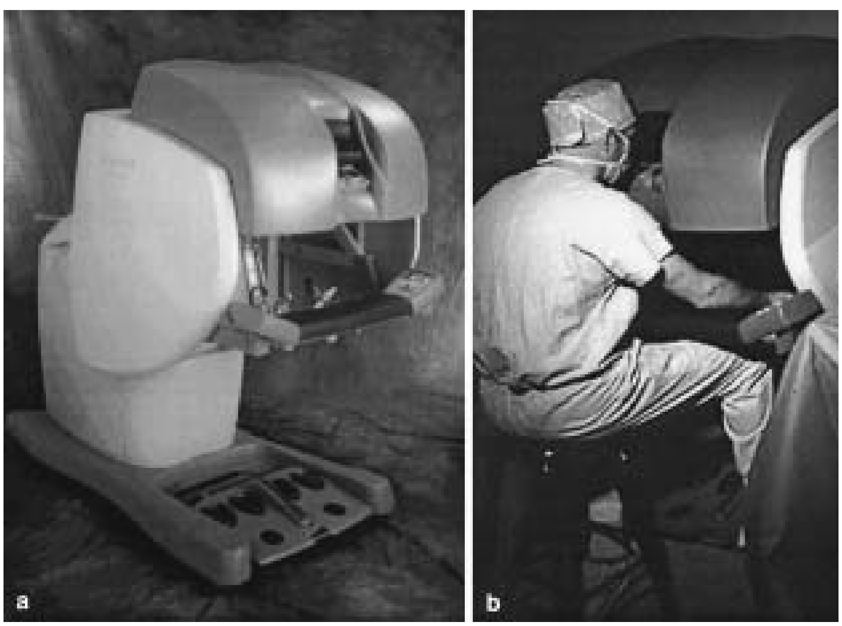
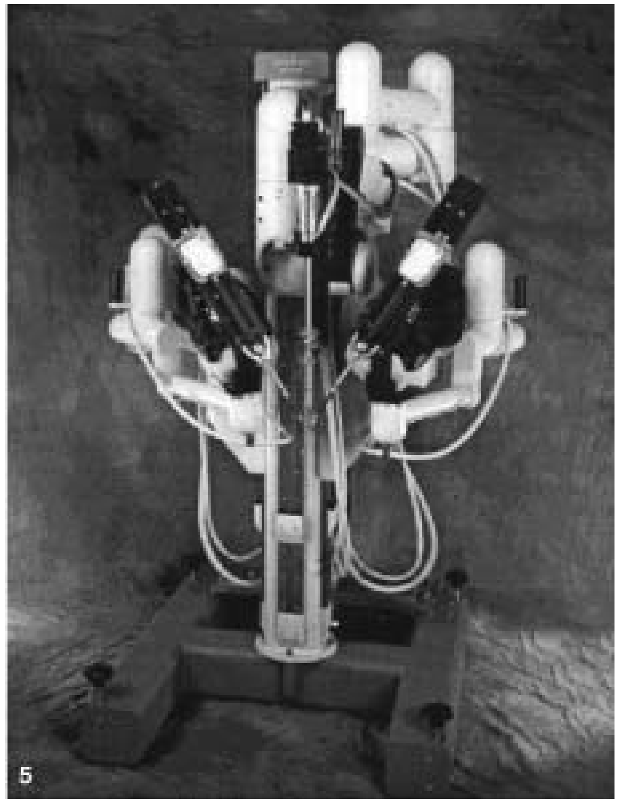


Fig. 3. The DA VINCI in 1999: computer is integrated in the console.

beings were performed as early as March 1997 [8]. Since then, we performed a nonconsecutive series of 39 procedures for gastroesophageal reflux (36 Nissen and 3 Toupet), 48 cholecystectomies, 28 fallopian tube reanastomoses, 10 gastroplasties for obesity, 3 intrarectal procedures, 3 inguinal hemias, 2 hysterectomies, 2 cardiac procedures, 2 prostatectomies, 2 arteriovenous fistulas, 1 lumbar sympathectomy, 1 appendectomy, 1 laryngeal exploration, 1 varicocele ligation, 1 endometriosis cure, 1 neosalpingostomy, 1 deferent canal reanastomosis. We have been working with the engineers from Intuitive Surgical since 1997. The "robot" went through several steps of evolution. More specifically, we went from a prototype (Mona) (Figs. 1, 2a,b) to the present "Da Vinci" (Fig. 3a,b) system.

During this evolution, we gradually eliminated the need for an



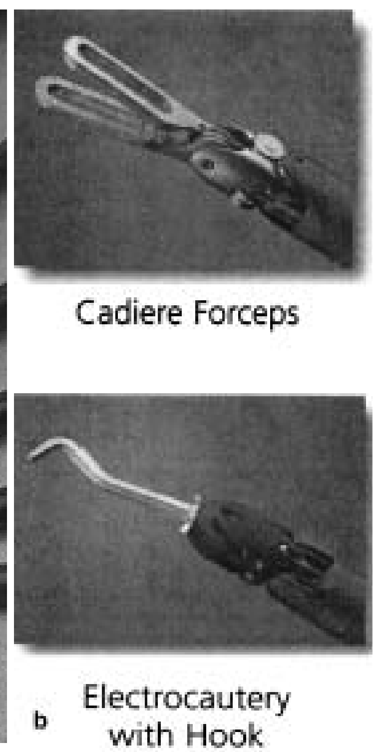


Fig. 4. The handles look like articulated joysticks. Three-dimensional vision through binoculars.

Fig. 5. The robot arms are mounted on a cart.

Fig. 6. a. Disposable, articulated tools that can be snapped onto the robot arms. **b.** Note the coagulating hook and the grasper created by the Saint-Pierre hospital and Intuitive Surgical engineers for cholecystectomy, obesity surgery, and Nissen fundoplication.

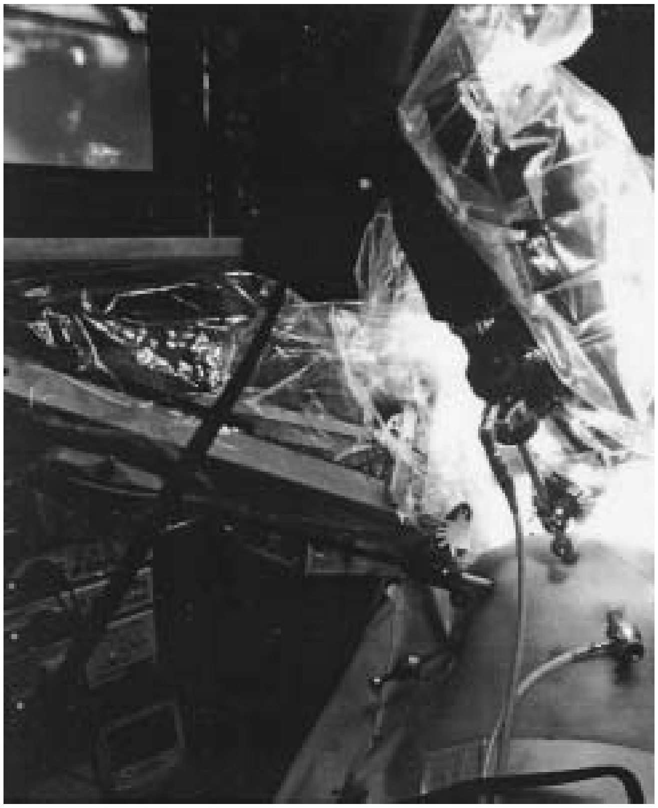


Fig. 7. Robot-specific trocar placement.

Table 1. Overview of cases.

Interventions	Number	Operating time median/minutes	Hospital stay median/days
Cholecystectomy	48	62 (20–135)	2 (1–15)
Nissen+ Toupet	39	90 (54–270)	2 (1–4)
Tubal reanastomosis	28	125 (108–244)	1 (1–2)
Gastroplasty	9	60 (55–90)	2 (2–3)
Inguinal hernia	3	60 (50–79)	1 (1)
Intrarectal procedure	3	65 (60–79)	1 (1–2)
Hysterectomy	2	120	3
Appendectomy	1	40	2
Laryngoscopy	1	30	1
Varicocele	1	27	1
Lumbar sympathectomy	1	40	5

engineer to be present at all times, and we experienced a constant improvement in ergonomics and electronic performance at the console. The bulk of the robot was significantly reduced and the tools were improved according to the needs for each procedure.

The Da Vinci system consists of two primary components: the surgeon's viewing and control console and a movable cart with three articulated robot arms. The surgeon is seated in front of the console and manipulates handles that are similar to "joysticks" while viewing a high-resolution, truly three-dimensional image of the surgical field through binoculars (Fig. 4).

Manipulation of the handles transmits electronic signals to the computer, which can control and modify the movement of instrument tips by downscaling the movements between (5:1 to 2:1), by eliminating physiologic tremor, and by adjusting grip strength applied to the tools. The computer generates electrical impulses that are transmitted by a 10 meter long cable and command the three articulated robot arms (Fig. 5).

Disposable laparoscopic (Fig. 6a,b) articulated instruments are attached to the distal part of two of these arms and introduced inside the abdomen through trocars mounted on the arms. The third arm carries an endoscope with dual optical channels, one for each of the surgeon's eyes.

In every procedure the optimal placement of the slave arm trolley had to be determined in order to accommodate the operating table and to avoid crowding by the slave arms' volume. In addition, the operative strategy had to be rethought in order to accommodate not only the changed trocar placement but also the new situation obtained by the articulated instruments with a different reach than the regular laparoscopic tools (Fig. 7). Operating time, perioperative morbidity, and hospital stay were registered by independent observers. Operating time was defined as the time between the moment the robot was wheeled over the patient and the trocar removal (system time).

To standardize our data, we chose to present the figure of the operating time for the last 21 Nissens, 23 cholecystectomies, 27 tubal reanastomoses, and 10 obesity surgeries. The operating time includes the procedure time: the time between the start of the cart setup and its removal; the system time: from positioning the surgical cart over the patient to disconnection of the system; and the dissection time: the surgeon's active time at the console. All the data were registered on the Da Vinci system at Saint-Pierre hospital.

Results (Table 1)

Gastroesophageal Reflux Procedure

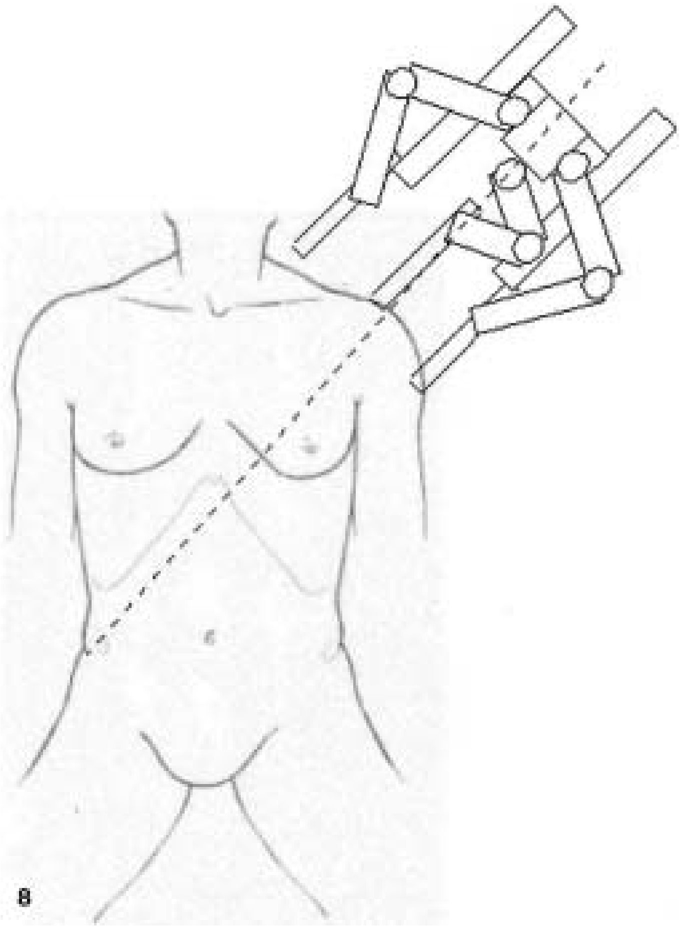
In performing a total of 39 procedures for gastroesophageal reflux (GERD) (36 Nissen, 3 Toupet), we found that the optimal position for the robot was with the surgical cart located to the patient's right, at the level of the patient's head, at a 45 degree angle with the table axis (Fig. 8). Placement of the trocars can be seen on Figure 9: three trocars are used for robotic instrument and scope, one additional trocar is used for a liver retractor, and a fifth trocar is used by the assistant.

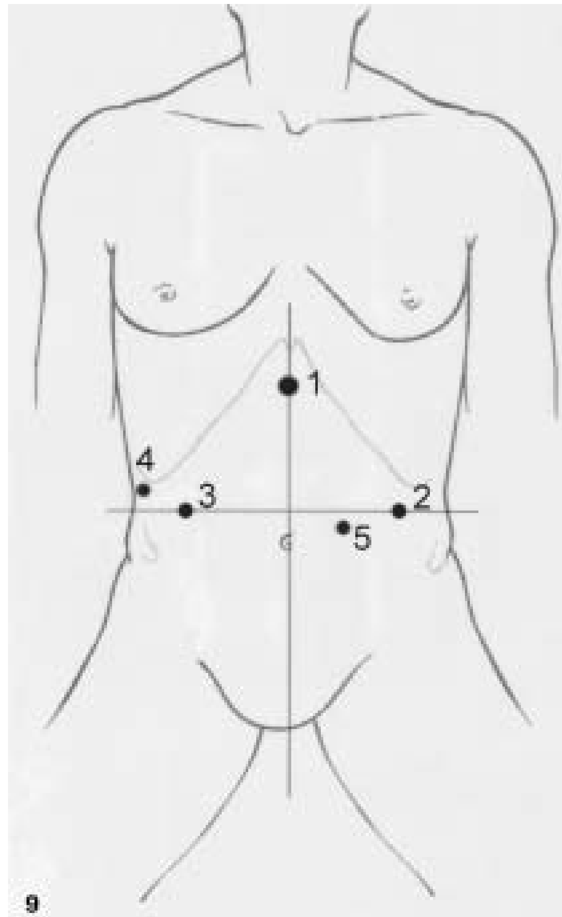
Median system time of the 21 Saint-Pierre hospital patients was 82 minutes (54–125). We experienced two complications: one trocar perforated the stomach, and the tear was repaired by robot suturing; one bleeding at the greater curvature was treated laparoscopically. Median hospital stay was 2 days (1–4) (Fig. 10).

Cholecystectomy

We performed a total of 48 cholecystectomies. The optimal trocar placement we found was with the surgical cart located to the left, at the level of the patient's head, at a 45 degree angle with the table axis (Fig. 11). The position of the trocars can be seen on Figure 12: three trocars are used for robotic instrument and scope, and one additional trocar is used for a liver retractor.

Median operating time of the last 35 cholecystectomies, all performed at our hospital with the Da Vinci system, was 70 minutes (25–120). Among the last 4 cases, gallbladders showed extended acute inflammation. We encountered one complication: a perioperative bleeding which necessitated transfusion of one





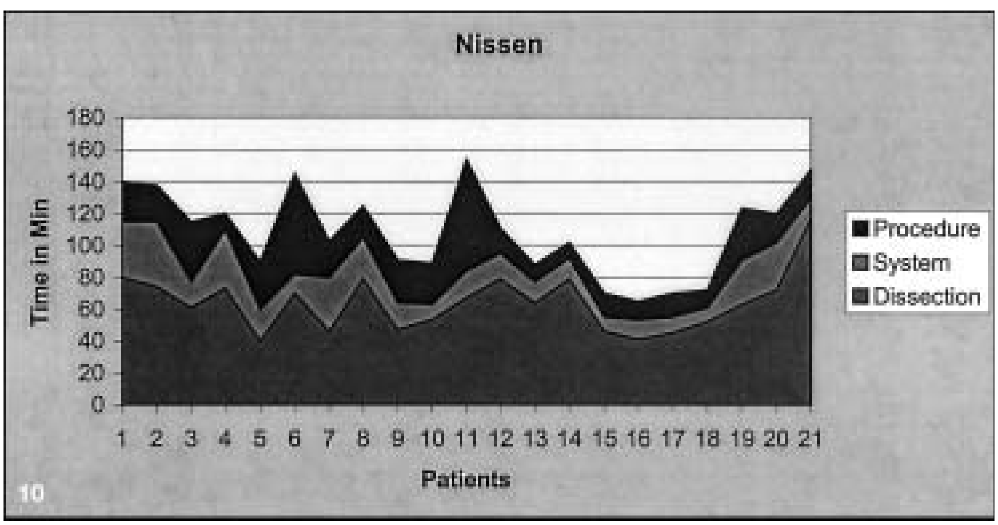


Fig. 8. Robot positioning.

Fig. 9. Trocar positioning.

Fig. 10. Last 21 Nissen procedures performed with Da Vinci at Centre Hospitalier Universitaire Saint-Pierre. Dissection time: The surgeon starts at the console. System time: From positioning the surgical cart over the patient to disconnection of the system. Procedure time: The time between the start of the cart setup and its removal.

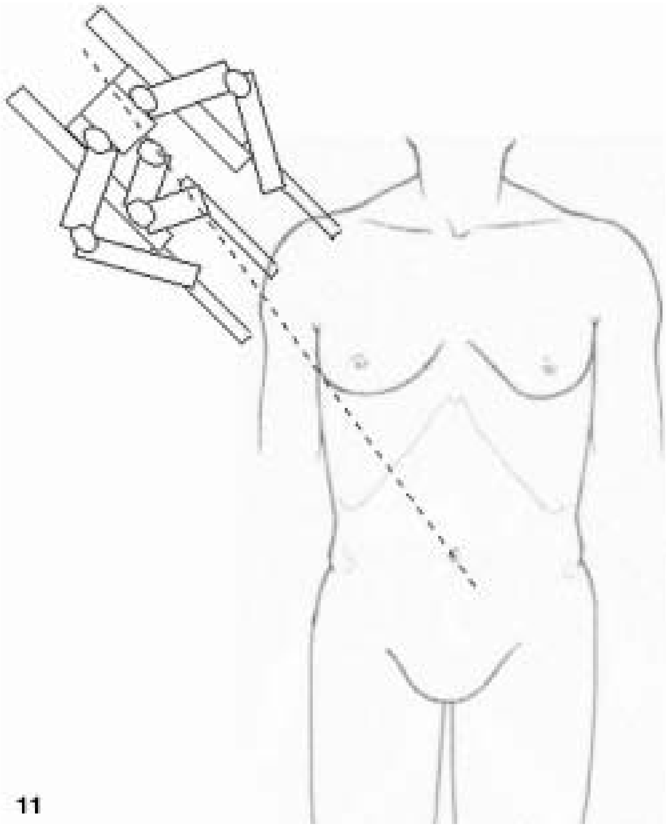
unit of blood for a hemoglobin value of 8 g/dl. Median hospital stay was 2 days (1–15) (Fig. 13).

Fallopian Tube Reanastomosis

Fallopian tube reanastomosis was performed in 28 patients at Saint-Pierre hospital. Median operating time for a double reanastomosis was 122 minutes (108–244). We did not encounter complications. Median hospital stay was 1 day (1–2). (Fig. 14–16).

Gastroplasty

We performed 10 gastroplasty procedures for obesity. The optimal position for the robot was found to be with the surgical cart



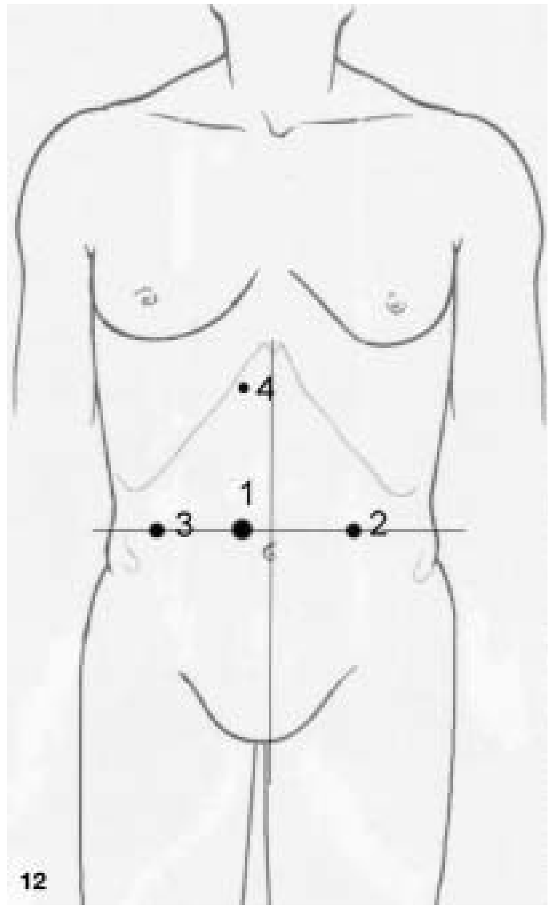


Fig. 11. Robot positioning.

Fig. 12. Trocar positioning.

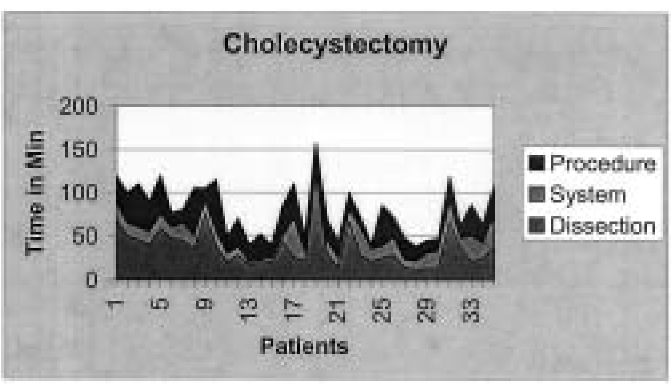


Fig. 13. Last 35 cholecystectomies performed with Da Vinci at CHU Saint-Pierre. Dissection time: The surgeon starts at the console. System time: From positioning the surgical cart over the patient to disconnection of the system. Procedure time: The time between the start of the cart setup and its removal.

located to the right, at the level of the patient's head, at a 45 degree angle with the table axis (Fig. 17). Trocar placement can be seen on Figure 18: three trocars are used for robotic instrument and scope, one additional trocar is used for a liver retractor, and a fifth trocar is used by the assistant.

Median system time was 60 minutes (55–90). Median hospital stay was 2 days (2–3). We did not encounter complications (Fig. 19).

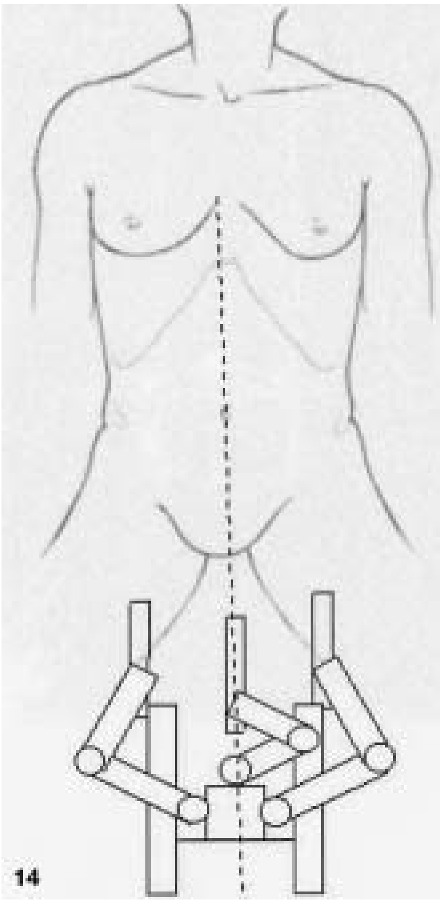
Transanal Intrarectal Resection

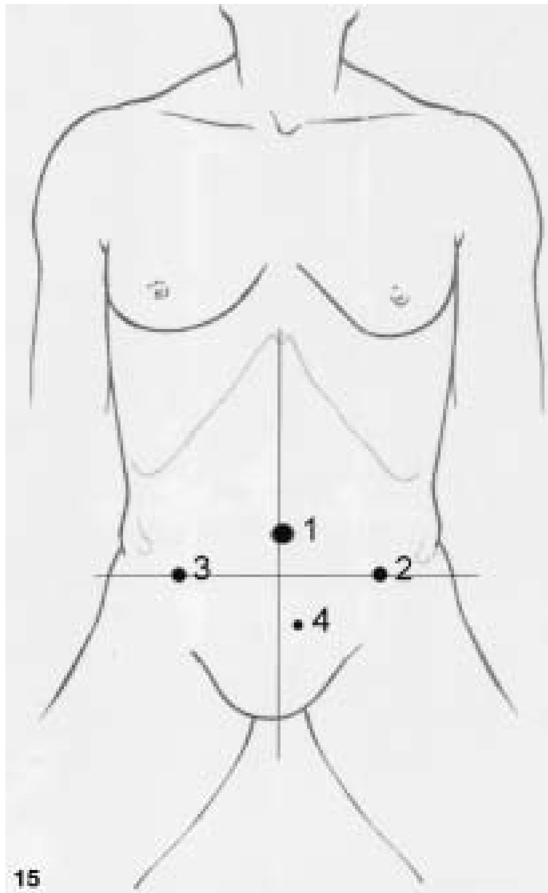
Transanal intrarectal resection was performed on 3 patients. The best trocar placement, we found, was with the surgical cart located to the patient's left. Only the two manipulating arms are occupied by the robot and were introduced through the anus. A conventional laparoscopic optical system was held by an assistant.

Median system time was 65 minutes (60–70). Median hospital stay was 1 day (1–2). We did not encounter complications (Figs. 20–22).

Discussion

We believe that all procedures performed with a telemanipulated robot were actually world premieres [8, 9]. Because of the novel character of the procedures, we had to thoroughly inform our patients on all possible implications of this new technology. We also needed to establish quickly the absence of any specific morbidity. The operating times of Nissen fundoplication for GERD and of cholecystectomy depended on a considerable number of parameters: (1) different operating sites (Paris, Brussels, Mexico City); (2) training of the entire team of doctors, nurses, and technicians for this new technology; (3) surgeon's learning curve as for any new operation; and (4) ongoing improvements on the system, in terms of ergonomics, console setup, computer performance, and tools evolution. The procedures discussed here, however, were all performed at our hospital in Brussels, hence the parameters mentioned above did not influence the operative time.





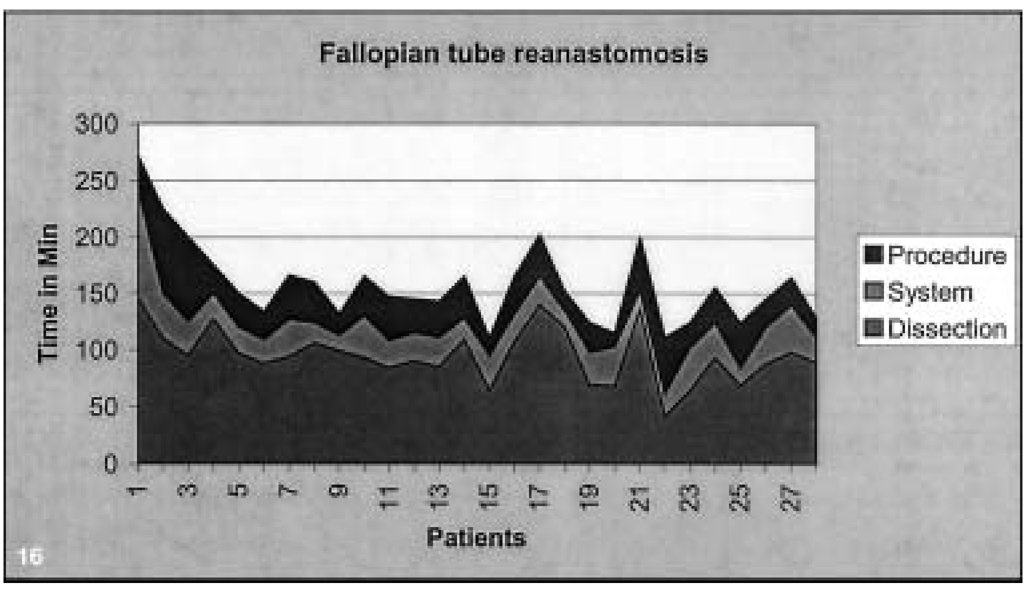


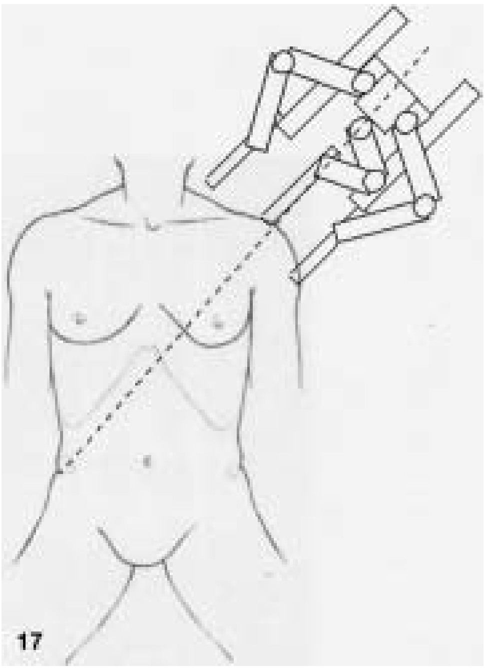
Fig. 14. Robot positioning.

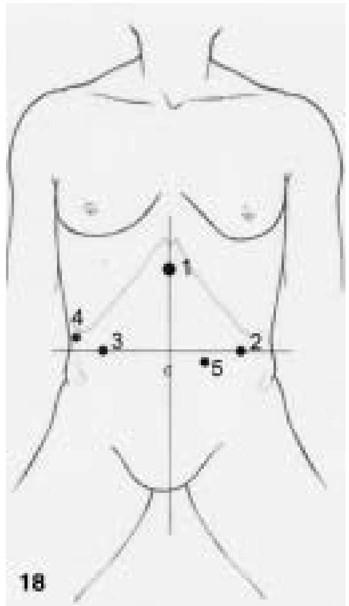
Fig. 15. Trocar positioning.

Fig. 16. Tubular reanastomosis procedures with Da Vinci in Saint-Pierre hospital. Dissection time: The surgeon starts at the console. System time: From positioning the surgical cart over the patient to disconnection of the system. Procedure time: The time between the start of the cart setup and its removal.

Gastroesophageal Reflux Procedure

Trocar position was slightly different from conventional laparoscopy because of the volume of the articulating arms. Operating time compares favorably with our first 80 conventional laparoscopic procedures [10]. Articulated tools brought a clear benefit while dissecting behind and around the esophagus. Hence it might be possible in the future to perform a less extended dissection at the level of the peritoneal attachments of the stomach's cardia. This dissection is unique in the laparoscopic approach and is performed for safety reasons [11]. The articulated tools make the procedure easier, safer, and more similar to the open procedure





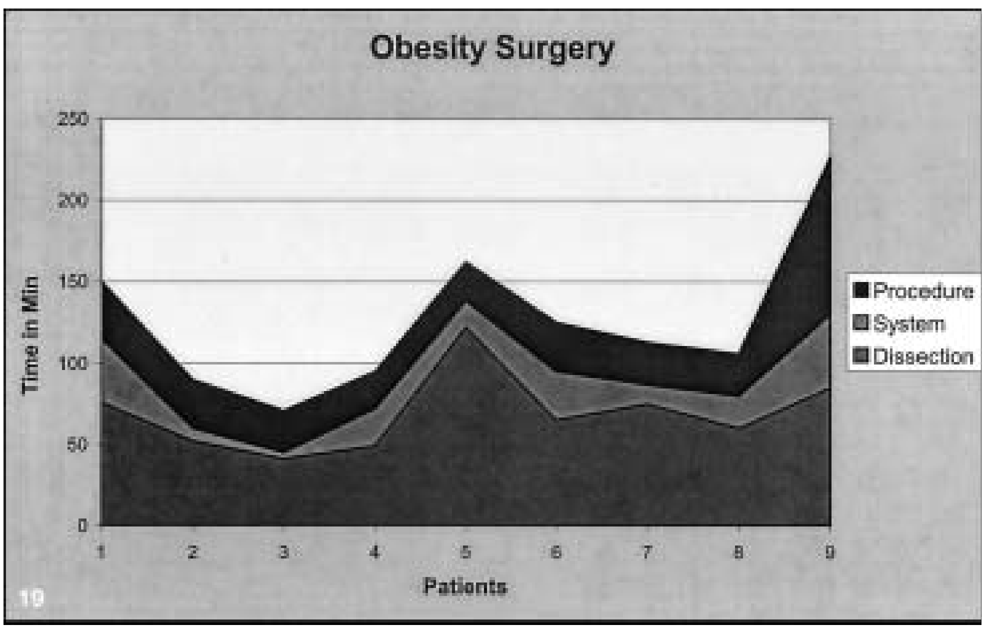


Fig. 17. Robot positioning.

Fig. 18. Trocar positioning.

Fig. 19. Nine of the ten gastroplasty procedures with Da Vinci in Saint-Pierre hospital. Dissection time: The surgeon starts at the console. System time: From positioning the surgical cart over the patient to disconnection of the system. Procedure time: The time between the start of the cart setup and its removal.

[12]. Another step of the operation at which the articulations of the tools proved beneficial was during the dissection of the short gastric vessels, because the dissecting tools could always come perpendicular to the vessels, facilitating dissection. On the other hand, we did experience a significant drawback of the robot system in its present configuration: the three-dimensional optical system is characterized by a very narrow field of vision. Therefore, we often had to interrupt the dissection to reposition the optics. These frequent interruptions, as well as the absence of a general view of the operative field, might have been responsible for the bleeding we encountered while dissecting the greater curvature with the robotic system, which made us convert into conventional laparoscopic approach.

Suturing the wrap became more straightforward, as it was easier to follow the curve of the needle while driving the suture through tissues. We experienced a clear improvement in tying the knots, thanks to the articulated tools. Evaluation of the knots' tension is, however, more difficult, because there is no tactile feedback. The theoretical advantage brought by downscaling did not add any clear benefit in the fundoplication as compared with the laparoscopic technique.

Cholecystectomy

We had to change the trocar position in order to accommodate the robot arms. We experienced significant benefit from the ar-

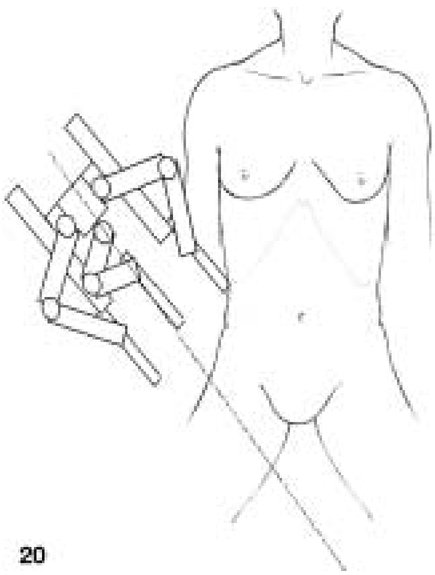


Fig. 20. Robot positioning.

Fig. 21. Placement of the articulated arms.

ticulated coagulating hook in dissecting the anterior and posterior peritoneal sheet at the level of Callot's triangle. We experienced similar benefit in dissecting the cystic duct and artery. The cystic duct could easily be ligated rather than clipped, just as in open surgery. The operating time (median of 51 minutes) depended merely on the degree of inflammation we encountered. We believe that the robot helped us in cases of acute cholecystitis. The operating time tended to decrease even further as we dealt with the learning curve.

Fallopian Tube Reanastomosis

The gold standard is still the open, microsurgical approach. The laparoscopic approach does not allow adequate microsuturing. In the robotic technique, however, operating time for the anastomosis was comparable to the gold standard, while hospital stay seemed to be shorter. With computer enhancement and downscaling, suturing became more straightforward and more accurate [13]. The surgeons could rest their hands and all tremor was eliminated.

Gastroplasty

It is usually difficult to manipulate conventional laparoscopic instruments, as the thickness of the patient's body wall impairs the mobility of trocars and ancillary tools. Articulated instruments dealt well with this condition. The problems of ergonomics encountered with the massively obese were obviously solved by placing the surgeon at a remote working console.

Transanal Intrarectal Procedures

The surgical tools are very tangential with the lesion [14]. The three-dimensional image, together with the fully mobile articulations brought every millimeter of the small cavity within reach and at a 90 degree angle of approach. Fingertip motions were accurately transposed by the robot arms. The remaining problem lies in instrument volume and an optical system which would need to be introduced transanally.

The new system was used in retroperitoneal procedures as well (retroperitoneal lumbar sympathectomy, preperitoneal inguinal hernioplasty). This demonstrated the possibility to benefit from computer enhancement even in very confined working spaces. Relatively complicated tasks like unfolding a mesh were successfully achieved without problems.

Operative time not only depended on the surgical dissection but on the installation of the system as well. The procedure time including all the setup depended on the intensive training of the surgical team. This novel type of surgery indeed created the need for a new function, an individual dedicated exclusively to the proper functioning of the robot during the operation. We elected to call this person a clinical technician. This individual needs a clinical background as well as a technical background. The technician's competence influences the time and the safety of the procedure. We did not encounter robot-specific morbidity and the hospital time was comparable to the conventional laparoscopic approach.

Conclusions

1. This study demonstrates the feasibility of robotic laparoscopic surgery on humans in different procedures, without specific morbidity, and within acceptable operating times.
2. In its present configuration, the system seems most beneficial when microsuturing within the abdomen or in very confined spaces.
3. Improved ergonomic conditions and improved instrument motility at the level of the distal articulation seem beneficial in the usual abdominal procedures. More research is needed for further improvement in tool shape and optics embodiment for this type of approach.
4. The robotic approach requires new operative strategies and a change in the pattern of trocar placement.

Résumé

L'interface computérisée qui commande un système mécanique (robot) permet de: 1) récupérer bon nombre de degrés de liberté perdus, grâce à des articulations intra-abdominales, 2) obtenir un meilleur contrôle visuel de la manipulation instrumentale grâce à une vision en trois dimensions 3) moduler l'amplitude des

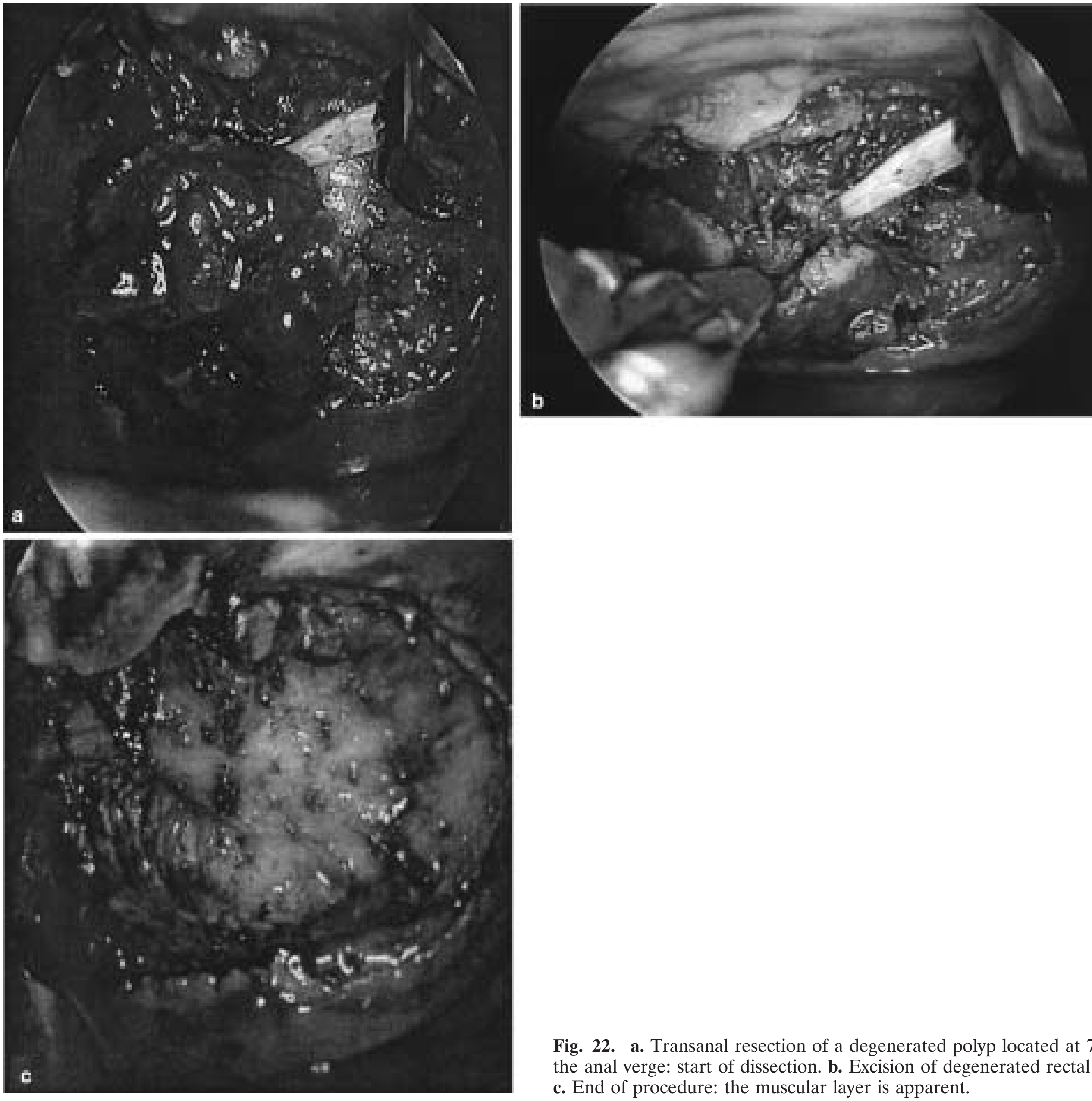


Fig. 22. **a.** Transanal resection of a degenerated polyp located at 7 cm from the anal verge: start of dissection. **b.** Excision of degenerated rectal polyp. **c.** End of procedure: the muscular layer is apparent.

mouvements chirurgicaux par démultiplication et stabilisation 4) travailler à une certaine distance du patient. Ces progrès ont permis d'améliorer la qualité de certains gestes chirurgicaux, essentiellement en raison d'améliorations ergonomiques. Le premier procédé assisté par robot chez l'homme a été réalisé chez nous en mars 1997. Entre cette date et janvier 2000, 85 patients ont eu une chirurgie laparoscopique assistée par robot : une série non-consécutive de 25 procédés antireflux, 34 cholécystectomies, 11 réperméabilisations de trompe, 4 gastroplasties pour obésité, trois hernies inguinales, 3 procédés intra-rectaux, une sympathectomie lombaire, une hystérectomie, une exploration laryngée, une ablation de varicocèle et une appendicectomie. Le robot (système Da Vinci, Intuitive Surgical, Mountain View, Ca) consiste en une console et une tour qui soutient trois bras articulés. Le chirurgien s'assied devant le console. Il manipule des manches qui ressemblent à des joystick tout en observant le champs opératoire à travers des optiques qui transforment l'image en trois dimensions. Cet ordinateur est capable de moduler ces données en éliminant le tremblement physiologique et en démultipliant l'amplitude des mouvement de 5 ou 3 à 1. Cette étude démontre la faisabilité de plusieurs procédés robotisés. La morbidité et al durée d'hospitalisation des patients étaient dans des limites acceptables. Le système apparat être plus efficace pour les procédés de microchirurgie intra-abdominale ou pour les manipulations dans un espace restreint. Une optimisation de l'ergonomique combinée à une mobilité accrue des extrémités des instruments contributent à l'amélioration dans beaucoup de procédés chirurgicaux abdominaux.

Resumen

Un ordenador interfaz que dirija un sistema mecánico (robot) permite al cirujano: 1) Recuperar, gracias a los separadores articulares intra-abdominales, una gran libertad de movimiento en su actuación quirúrgica. 2) Mejor manipulación de los instrumentos, gracias a un control visual más adecuado merced a la visión tridimensional. 3) Modular los movimientos de la mano quirúrgica, merced a una mayor estabilización y menor oscilación. 4) Trabajar a distancia del paciente. Estos avances aumentan la calidad del acto quirúrgico debido, en último término, a una extraordinaria mejora de la ergonomía. La primera intervención asistida por un robot, la realizó nuestro equipo en marzo de 1997. Entre esta fecha y enero de 2000, 85 pacientes fueron operados laparoscópicamente con ayuda de un robot; se realizaron 25 intervenciones antirreflujo, 34 colecistectomías, 11 repermeabilizaciones tubáricas, 4 gastroplatias por obesidad, 3 hernias inguinales, 3 intervenciones intrarrectales, 1 simpatectomía lumbar, 1 histerectomía, 1 exploración laríngea, 1 varicocelectomia y 1 apendicectomía. E1 robot (Sistema Da Vinci, Intuitive Surgical, Mountain View, Ca.) consiste en una consola y una torre que soporta los 3 brazos articulados del robot. E1 cirujano, sentado enfrente de la consola maneja unos mandos en forma de palanca, mientras observa el campo operatorio a través de unos binoculares que le proporcionan una visión tridimensional. E1 ordenador es capaz de modular la manipulación, disminuyendo de 3 a 5 veces la amplitud de los movimientos y eliminando el temblor fisiológico. Este estudio muestra la posibilidad de realizar gran número de intervenciones robóticas. La morbilidad y estancia hospitalaria estuvieron dentro de unos límites aceptables. Este sistema parece ser el más eficaz para la microcirugia intra-abdominal y para cualquier manipulación en un reducido espacio. Para la mayoría de las intervenciones de cirugía abdominal la optimización ergonómica y el incremento de la movilidad de la punta de los instrumentos quirúrgicos, son muy útiles y provechosas. **a.** Disposable, articulated tools that can be snapped onto the robot arms. **b.** Note the coagulating hook and the grasper created by the Saint-Pierre hospital and Intuitive Surgical engineers for cholecystectomy, obesity surgery, and Nissen fundoplication.

References

1. Dion, Y.M., Gaillard, F.: Visual integration of data and basic motor skills under laparoscopy. Influence of 2-D and 3-D video-camera systems. Surg. Endosc. *11*:995, 1997
2. McDougall, E.M., Soble, J.J, Wolf, J.S., Jr., Nakada, S-Y., Elashry, O.M., Clayman, R.V.: Comparison of three-dimensional and two-dimensional laparoscopic video systems. J. Endoural. *10*:371, 1996
3. Voorhorst, F.A., Overbeeke, C.J., Smets, G.J.: Spatial perception during laparoscopy: implementing action-perception coupling. Stud. Health Technol. Inform. *39*:379, 1997
4. Berguer, R., Rab, G.T., Abu-Ghaida, H., Alarcon, A., Chung, J.: A comparison of surgeons' posture during laparoscopic and open surgical procedures. Surg. Endosc. *11*:2139, 1997
5. Wappler, M.: Medical manipilators, a realistic concept? Minim. Invasive Ther. *4*:261, 1995
6. Garcia-Ruiz, A., Gagner, M., Miller, J.H., Steiner, C.P., Hahn, J.F.: Manual vs robotically assisted laparoscopic surgery in the performance of basic manipulation and suturing tasks. Arch. Surg. *133*:9957, 1998
7. Garcia-Ruiz, A., Smedira, N.G., Loop, F.D., Hahn, J.F., Miller, J.H., Steiner, C.P., Gagner, M.: Robotic surgical instruments for dexterity enhancement in thoracoscopic coronary artery bypass graft. J. Laparoendosc. Adv. Surg. Tech. A. *7*:5277, 1997
8. Himpens, J., Leman, G., Cadière, G.B.: Telesurgical laparoscopic cholecystectomy. Surg. Endosc. *12*:81091, 1998
9. Cadière, G.B., Himpens, J., Vertruyen, M., Favretti, F.: The world's first obesity surgery performed by a surgeon at a distance. Obes. Surg. *9*:206, 1999
10. Cadière, G.B., Houben, J.J., Bruyns, J., Himpens, J., Panzer, J.M., Gelin, M.: Laparoscopic Nissen fundoplication technique and preliminary results. Br. J. Surg. *81*:400, 1994
11. Cadière, G.B., Himpens, J., Bruyns, J.: How to avoid esophageal perforation while performing laparoscopic dissection of the hiatus. Surg. Endosc. *9*:450, 1995
12. Satava, R.M.: Emerging technologies for surgery in the 21st century. Arch. Surg. *134*:1197, 1999
13. Garcia-Ruiz, A., Gagner, M., Miller, J.H., Steiner, C.P., Hahn, J.F.: Manual vs. robotically assisted laparoscopic surgery in the performance of basic manipulation and suturing tasks. Arch. Surg. *133*:957, 1998
14. Mentges, B., Buess, G., Schafer, D., Mancke, K., Becker, H.D.: Local therapy of rectal tumor. Dis. Colon Rectum *39*:8886, 1996