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SURGICAL ENDOSCOPY
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What is the value of telerobotic technology in gastrointestinal surgery?

A. Perez, M. J. Zinner, S. W. Ashley, D. C. Brooks, E. E. Whang

Department of Surgery and Division of Minimally Invasive Surgery, Brigham and Women's Hospital, Harvard Medical School, 75 Francis Street, Boston, MA 02115, USA

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Abstract
Background: Although telerobotic technology has entered clinical application, its value for gastrointestinal surgery is unclear. Our objective was to evaluate the performance characteristics of telerobotically assisted laparoscopic cholecystectomy (TALC).
Methods: All TALCs performed using the da Vinci Surgical System between January 2000 and September 2001 at a tertiary academic medical center were analyzed.
Results: For this study, 20 patients (80% female) with a mean age of 47 ± 4 years underwent TALC. All had symptomatic cholelithiasis, and all had successful TALC results without complications or need for conversion to conventional laparoscopic cholecystectomy (CLP). The mean procedure time was 152 ± 8 min. The procedures were performed by one of three staff surgeons experienced in laparoscopic surgery who had training in telerobotic surgery. The perceived advantages of TALC over CLP included easier tissue dissection, enhanced dexterity, and stimulated interest in biliary surgery. The disadvantages included increased operating time and lack of tactile feedback.
Conclusions: The TALC procedure is effective and safe when performed by appropriately trained surgeons. Telerobotic technology has the potential to reinvigorate gastrointestinal surgery.

Key words: Telerobotic — Laparoscopic — Cholecystectomy — Gastrointestinal surgery

The feasibility of telerobotically assisted surgery has been demonstrated for a wide range of procedures including gastrointestinal, cardiothoracic, gynecologic, neurologic, ophlamologic, orthopedic, otolaryngologic, pediatric operation as well as plastic and reconstructive, thoracic, and urologic operations [1–20]. Although telerobotic surgical technology already has entered clinical practice in select settings, its ultimate value and potential for widespread application remain unknown. In this analysis, we evaluated our initial experience with telerobotic technology in the context of a single gastrointestinal procedure: telerobotically assisted laparoscopic cholecystectomy (TALC).

Materials and methods

All the TALCs performed at Brigham and Women's Hospital during the period spanning January 1, 2000 through September 1, 2001 were analyzed. The da Vinci Surgical System (Intuitive Surgical, Mountain View, CA, USA) was used in each case. The procedures were performed by one of three staff surgeons experienced in laparoscopic surgery who had undergone dedicated training in robotic surgery consisting of didactic lectures combined with animal and cadaver laboratory sessions. They were assisted by 1 of 12 senior surgical residents experienced in conventional laparoscopic surgery.

At the end of the study period, an electronic survey was sent via e-mail to the three surgeons who had performed the TALCs and to the 12 surgical residents who had assisted with these procedures. The survey consisted of five questions (3 multiple-choice questions and 2 open-ended questions) regarding the perceived advantages and disadvantages of TALC relative to conventional laparoscopic cholecystectomy.

Data are expressed as mean ± SEM. Means were compared using analysis of variance (ANOVA). Statistical significance was indicated by p values less than 0.05.

Results

The first application of telerobotic surgical technology at our institution was TALC, and the cases comprising this series involved the initial TALCs performed. During the study period, 20 TALCs were performed at our institution. These 20 TALCs represent 6% of all the laparoscopic cholecystectomies performed (n = 364) by

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Correspondence to: E. E. Whang

Table 1. Length of procedure time

	Conventional laparoscopic cholecystectomy		TALC	
Surgeon	*n*	Time (min)	*n*	Time (min)
1	126	117 ± 2	1	189 ± 0
2	79	135 ± 4	3	178 ± 28
3	139	103 ± 2	16	144 ± 8[a]
Total	344	116 ± 2	20	152 ± 8[a]

Data expressed as mean ± SEM
[a] $p < 0.05$ versus conventional laparoscopic cholecystectomy
TALC, telerobotically assisted laparoscopic cholecystectomy

Table 2. Perceived advantages of telerobotically assisted laparoscopic cholecystectomy over conventional laparoscopic cholecystectomy

Advantage	%[a]
Easier tissue dissection	60
Enhanced dexterity	60
Tele-education	50
Technological integration	40
Tele-presence	40
Tele-mentoring	40
Stereoscopic vision	40
Surgical training tool	30
Increased surgeon comfort	30
Stimulated interest in biliary surgery	30

[a] Percentage of survey respondents who perceived an advantage of telerobotic technology over conventional laparoscopic techniques with respect to each of these factors

Table 3. Perceived disadvantages of telerobotically assisted laparoscopic cholecystectomy relative to conventional laparoscopic cholecystectomy

Disadvantage	%[a]
Lack of tactile feedback	25
Prolonged setup time	25
Prolonged procedure time	17
Difficult patient access in an emergency	17
Added expense	8
Larger operating room needed to accommodate the robotic unit	8
Cumbersome equipment	8

[a] Percentage of survey respondents who perceived a disadvantage of telerobotic technology relative to conventional laparoscopic techniques with respect to each of these factors

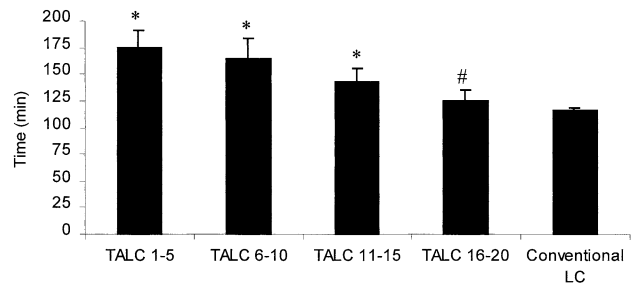

Fig. 1. Institutional learning curve. TALC, telerobotic-assisted laparoscopic cholecystectomy; Conventional LC, conventional laparoscopic cholecystectomy. * $p < 0.05$ vs conventional LC; # $p < 0.05$ vs TALC 1–5.

the three participating staff surgeons during the study period.

The mean age of the patients who underwent TALC was 47 ± 4 years, and 16 (80%) were women. The indication for surgery was symptomatic cholelithiasis in all cases. All 20 patients underwent successful TALC without the need for conversion to conventional laparoscopic or open cholecystectomy. There were no intraoperative or postoperative complications.

The TALC procedure was associated with a significantly longer mean operative time than required by conventional laparoscopic cholecystectomy performed by the participating staff surgeons during the study period (152 ± 8 vs 116 ± 2 min, respectively; $p < 0.05$) (Table 1). The overwhelming proportion of the operative time associated with TALC was related to telerobotic positioning and adjustments rather than surgeon-directed tissue manipulation.

An institutional learning curve with respect to operative time was observed (Fig. 1). The mean operative time for the final five TALCs was not significantly different ($p = 0.51$) from that associated with conventional laparoscopic cholecystectomy performed by the participating staff surgeons.

The cost associated with the instrumentation used in TALC was $16,400 per case. The instruments used in TALC are reusable, with most of the items approved for use in 10 separate procedures. The cost associated with the instrumentation used in conventional laparoscopic cholecystectomy was $3,857 per case. Reusable laparoscopic instruments were used in all conventional laparoscopic cases.

Of the staff surgeons and residents surveyed, 13 (87%) responded. Of these respondents, 77% perceived some advantage of TALC over conventional laparoscopic cholecystectomy. Ease of tissue dissection, enhanced dexterity, and the potential for teleeducation were the most frequently cited advantages. Interestingly, 30% of the respondents indicated that introduction of TALC into the general surgery residency program had noticeably stimulated interest in laparoscopic surgery in general and biliary surgery in particular at all levels.

Most of the respondents (92%) perceived some disadvantage of TALC relative to conventional laparoscopic cholecystectomy. Lack of tactile feedback and prolonged robotic apparatus setup time were the most frequently cited disadvantages (Table 1). Only 8% of the respondents cited the increased expense associated with TALC as a disadvantage (Table 2).

Discussion

This report describes the initial experience with telerobotic surgical technology at our institution. Our experience suggests that this technology in its currently available form is safe and effective in the context of appropriate surgical training and patient selection.

During the study period, clinical application of telerobotic technology was limited to three staff surgeons experienced in laparoscopic surgery who had undergone dedicated training in the use of the da Vinci Surgical System. Although a learning curve with respect to operative time was observed, the reason for the decline in operative time may be more complex than is initially apparent. Apparatus setup, patient positioning, and instrument manipulations associated with the TALCs presented logistical challenges that required a concerted collaborative effort from the surgical, anesthesia, and nursing staff. The relative contributions to the total operative time made by the surgical, anesthesia, and nursing staff and the degree to which these times can be modified by experience or training will have important implications for the future of this procedure, particularly with respect to staffing and training.

The mean operative time for the final five TALCs comprising this experience approximated that for the conventional laparoscopic cholecystectomies performed by the participating staff surgeons during the study period. However, it is important to remember that the surgical indication for TALC was symptomatic cholelithiasis in all cases, whereas the conventional laparoscopic cholecystectomies were performed for a range of elective and emergency indications. The performance characteristics of TALC performed for indications other than symptomatic cholelithiasis remain to be defined.

Whether telerobotic surgical technology will enjoy widespread clinical application depends ultimately on its perceived cost–benefit profile. Some of the advantages and disadvantages surgeons perceived to be associated with this technology were identified in this study. Even with refinements in technology and reductions in cost, however, the issue of which particular procedures should be allocated to telerobotic surgery remains to be defined. An important area of analysis will involve matching this and other emerging technologies with those procedures most likely to derive benefit from their application.

Because this experience occurred at an academic medical center, surgical resident participation was integral to each procedure. An unanticipated finding of this study was that introduction of telerobotic surgery into the general surgery residency program stimulated vigorous interest in laparoscopic surgery in general and biliary surgery in particular. The application of telerobotic technology in the training of surgeons may ultimately be as important as its application in clinical practice.

References

1. Baca I (1997) Robot arm in laparoscopic surgery. Chirurg 8: 837–839
2. Barrett SF, Wright CH, Jerath MR, Lewis II RS, Dillard BC, Rylander III HG, Welch AJ (1995) Automated retinal robotic laser system. Biomed Sci Instrum 31: 89–93
3. Brandt G, Zimolong A, Carrat L, Merloz P, Staudte HW, Lavallee S, Radermacher K, Rau G (1999) CRIGOS: a compact robot for image-guided orthopedic surgery. IEEE Trans Inf Technol Biomed 4: 252–260
4. Buess GF, Schurr MO, Fischer SC (2000) Robotics and allied technologies in endoscopic surgery. Arch Surg 2: 229–235
5. Cadiere GB, Himpens J, Vertruyen M, Favretti F (1999) The world's first obesity surgery performed by a surgeon at a distance. Obes Surg 2: 206–209
6. Cheah WK, Lee B, Lenzi JE, Goh PM (2000) Telesurgical laparoscopic cholecystectomy between two countries. Surg Endosc 11: 1085
7. Chitwood Jr WR, Nifong LW, Chapman WH, Felger JE, Bailey BM, Ballint T, Mendleson KG, Kim VB, Young JA, Albrecht RA (2001) Robotic surgical training in an academic institution. Ann Surg 4: 475–484
8. Damiano Jr RJ, Tabaie HA, Mack MJ, Edgerton JR, Mullangi C, Graper WP, Prasad SM (2001) Initial prospective multicenter clinical trial of robotically assisted coronary artery bypass grafting. Ann Thorac Surg 4: 1263–1268
9. Hanisch E, Markus B, Gutt C, Schmandra TC, Encke A (2001) Robot-assisted laparoscopic cholecystectomy and fundoplication: initial experiences with the Da Vinci system. Chirurg 3: 286–288
10. Kavanagh KT (1994) Applications of image-directed robotics in otolaryngologic surgery. Laryngoscope 3: 283–293
11. Marescaux J, Smith MK, Folscher D, Jamali F, Malassagne B, Leroy J (2001) Telerobotic laparoscopic cholecystectomy: initial clinical experience with 25 patients. Ann Surg 1: 8–9
12. Margossian H, Falcone T (2001) Robotically assisted laparoscopic hysterectomy and adnexal surgery. J Laparoendosc Adv Surg Tech A 3: 161–165
13. Meininger DD, Byhahn C, Heller K, Gutt CN, Westphal K (2001) Totally endoscopic Nissen fundoplication with a robotic system in a child. Surg Endosc 11: 1360A–1360
14. Melvin WS, Needleman BJ, Krause KR, Wolf RK, Michler RE, Ellison EC (2001) Computer-assisted robotic heller myotomy: initial case report. J Laparoendosc Adv Surg Tech A 4: 251–253
15. Okada S, Tanaba Y, Sugawara H, Yamauchi H, Ishimori S, Satoh S (2000) Thoracoscopic major lung resection for primary lung cancer by a single surgeon with a voice-controlled robot and an instrument retraction system. J Thorac Cardiovasc Surg 2: 414–415
16. Partin AW, Adams JB, Moore RG, Kavoussi LR (1995) Complete robot-assisted laparoscopic urologic surgery: a preliminary report. J Am Coll Surg 6: 552–557
17. Satava RM (1999) Emerging technologies for surgery in the 21st century. Arch Surg 134: 1197–1202
18. Satava RM, Bowersox JC, Mack M, Krummel TM (2001) Contemp Surg 10: 489–499
19. Siemionow M, Ozer K, Siemionow W, Lister G (2000) Robotic assistance in microsurgery. J Reconstr Microsurg 8: 643–649
20. Young RF (1987) Application of robotics to stereotactic neurosurgery. Neurol Res 2: 123–128