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Fellowship training in robotic colorectal surgery within the current hospital setting - an achievable goal?

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Abstract

Purpose: Although currently limited, the requirement for colorectal trainees to attain skills in robotic surgery is likely to increase due to further utilisation of robotic platforms globally. The aim of the study is to describe the training program utilised and assess outcomes of fellowship training in robotic colorectal surgery.

Methods: A structured robotic training programme was generated across a tertiary hospital setting. Review of four prospectively maintained fellow operative logbooks was performed to assess caseload and skill acquisition. Operative and patient related outcomes were compared with consultant trainer performed cases. Data was analysed using R with a $p<0.05$ considered significant.

Results: The structured robotic training scheme is a two-tiered system over a 12-month period. The trainer-directed pathway comprised of a robotic console safety course followed by cart-side assisting, a wet lab animal course, dual-console accreditation training course and onsite proctoring, prior to becoming an independent console surgeon. Over 2 years,265 robotic(n=143 primary/component surgeon) cases were undertaken with fellows A,B,C and D involved in 63,77,75 and 50 robotic colorectal cases respectively. Individual learning curves revealed independent procedure competency at cases 11, 14, 15, and 12 respectively for robotic anterior resection. There was no significant difference observed in operative time (p=0.39), blood loss (p=0.41), lymph node harvest (p=0.35),conversion rates (2%v4%), anastomotic leaks (1%v3%) and R0 resection rates (100%v98% colonic,96%v96% rectal,p=0.48) between surgical fellows and consultant trainers. Clavien-Dindo(III-IV) complications were similar (10%v6%,p=0.25) with no mortalities encountered.

Conclusion: It is feasible and safe to train fellows in robotic colorectal surgery without compromise of operative and patient related outcomes.

Introduction:

Innovations in surgical robotic platforms have led to the advanced application of robotic approaches for benign and malignant abdominopelvic pathologies. Over the last number of years there has been an exponential rise in robotically performed cases globally (1, 2). Evidence to date has reported safety and efficacy comparable to open and laparoscopic approaches in many surgical subspecialties (3-5). The patient related benefits of robotic interventions reported in the literature have been similar to those of laparoscopic approaches with decreased blood loss and less post-operative pain with consequential reduced hospital length of stay and improved cosmesis. (6-8). Additionally several studies highlight improved technical outcomes when compared to laparoscopy due to 3-dimensional imaging, increased dexterity and articulation, stable camera platform and tremor elimination (9-11).

With the induction of any new invasive technology into clinical practice, it is crucial that a structured training programme is put in place with benchmarks for training set to ensure an appropriate level of skill acquisition is achieved which is then transferable and reproducible in the operating room (OR) (12). To date there have been numerous challenges for surgical trainees to acquire "hands on" operative training in the field of robotic surgery. Restricted working hours, operative time costs, medico legal considerations and presumed complex set-up have all been cited as factors hindering trainee surgeons from becoming proficient in robotic surgery (13, 14). The Halsted method of surgical training is no longer applicable in the current era and surgeons must adopt and master new skills safely and early in their learning curve to reduce patient harm. With the advent of any new technologies, the risk of adverse events occurs early in implementation and adoption (15). In order to mitigate such events, a training programme for surgeons interested in using such platforms is utilised prior to becoming independent, credentialed console surgeons (16). These curriculums, which are commonly mandatory by industry and health care facilities, invariably consist of a combination of surgical simulation and proctoring.

Currently, however, such robotic training pathways have not been formally dispersed and adopted amongst surgical training programmes. In addition the efficacy and patient related outcomes of such pathways are not commonly reported in the literature. The development of the dual robotic console could potentially herald the translation of such programmes into formal, structured robotic training for trainees. The aim of the study was to analyse the development and feasibility of fellowship training in robotic colorectal surgery in a public hospital setting and assess patient and oncological related outcomes in cases undertaken by trainees.

Methods:

Training pathway

The colorectal department at the Peter MacCallum Cancer Centre, Melbourne enlists two international colorectal fellows, annually, for a 12 month advanced colorectal surgical fellowship. This is obtained at competitive interview by trainees who have completed specialist colorectal training (8 – 10 years postgraduate training) in their respective countries. All fellows included in this study have performed greater than one hundred primary colorectal resections (elective/emergency) and completed their respective surgical fellowship exams prior to commencing at the unit. The fellowship focuses on minimally invasive and extended resection for lower gastrointestinal malignancy including robotics. A robotic training pathway was devised in 2018 encompassing both self-directed and trainer-directed streams with the goal of fellows becoming independent, credentialed robotic console surgeons on completion of the fellowship (Figure 1). All fellows undergo continuous assessment, simulator training and online module teaching, along with dry and wet lab courses with benchmarks set prior to transferring skills to the operating room. Case workload included robotic rectal and colonic resection and incisional hernia repair. A major proportion of cart side robotic assistance was undertaken by each fellow in the private sector (Epworth Hospital). Proctoring was undertaken at the Peter MacCallum by industry-appointed, credentialed proctors in robotic surgery. Continuous intra-operative and post-operative feedback was given throughout proctorship. Formal intra-operative feedback was provided by the proctor with further formalised feedback immediately post-operative to review steps performed well and areas requiring improvement. Further informal post-operative video-based peer feedback was undertaken for key components of the procedure (vessel ligation/TME dissection) with the proctor during the initial learning phase. A prospectively maintained logbook is maintained by all fellows, documenting cart-side assist, component surgeon and primary console surgeon cases throughout the year. The prospective learning curve for all fellows for common procedures were recorded, highlighting steps performed independently and steps observed/requiring assistance during surgical intervention. The protocols and procedures employed were ethically reviewed and approved through the institutional ethics committee at the Peter MacCallum Cancer Centre.

Case selection:

A review of prospectively maintained surgical databases was undertaken to identify all patients undergoing robotic surgery from January 2018 to July 2020. In oncological robotic resections, all patients were routinely discussed at a dedicated colorectal cancer multidisciplinary meeting prior to resection. The diagnosis and management of all cancers was based on preoperative radiological imaging and clinical assessment. Patient demographics (age, sex), neoadjuvant & adjuvant therapy regimen, surgical intent, type of surgery and complications were recorded. Histopathological assessment included distal and proximal margin status, circumferential resection margin (CRM, R status), and lymph node yield. Operative factors recorded included operative time, blood loss (mls) and conversion rates. Patient related post-operative outcomes recorded included anastomotic leaks, complications (Clavien-Dindo III-IV) and mortality. To assess the efficacy and safety of the structured training programme a comparative analysis was performed by examining patient, operative and oncological related outcomes in fifty consecutive colorectal resections independently performed by fellows and fifty consecutive consultant performed cases. All consultant surgeons included for comparison of patient related operative outcomes have been performing robotic colorectal resections more than five years and have contributed to international robotic trials with two surgeons regularly being employed as robotic colorectal proctors by industry.

Definitions:

Histopathological evaluation considered an R0 resection as a resection with a clear margin of >1mm. R1 resection was the presence of microscopic residual disease defined as a resection margin of ≤1mm, whereas R2 resection was the presence of macroscopic residual disease.

A wound infection is defined by the US Centre for Disease Control and Prevention (CDC) as surgical site infection (SSI) (23). This is further defined as superficial incisional SSI (recorded as grade1), deep incisional SSI (grade 2) or organ/space SSI (grade3)(17).

Anastomotic leakage was defined as a defect of the intestinal wall at the anastomotic site to a communication between the intra- and extraluminal compartments (18).

Complications were recorded according to the Clavien-Dindo classification and grade III -IV complications were included for analysis (19).

Statistical analysis:

Statistical analysis was performed using Microsoft Excel program and R with a p-value of less than 0.05 ($p<0.05$) considered significant. Baseline characteristics were summarized using descriptive statistics, including counts and frequencies for categorical variables and mean, standard deviation (SD), median and range for continuous variables.

Comparison of outcomes between two groups was performed using paired t-test and one-way Anova was used to analyse the means of three or more factors within the study.

Results:

Four fellows were enlisted in robotic colorectal surgical training during the study period from January 2018 to July 2020. 265 cases were undertaken at Peter MacCallum with fellow 1 (Jan 2018 – Jan 2019), 2 (July 2018 – July 2019), 3 (Jan 2019 – Jan 2020) and 4 (July 2019 – July 2020) being involved in 63, 77, 75 and 50 robotic colorectal cases, respectively (Figure 2).

All fellows performed mandatory cart-side assist cases prior to advancing to console operative time. Fellow 1 performed 31 cart-side assist cases with fellows 2, 3 and 4 performing 30, 36 and 25 cases, respectively. After completion of all simulator exercises, with appropriate benchmark scores achieved, a robotic safety course and an animal model wet lab course, fellows advanced to patient console operative time (Component surgeon) using the Intuitive Da-Vinci Xi dual-console. These surgical components were performed while the primary surgeon occupied the other console during the entire procedure. Operative technique, task management, situational awareness and assistant communication was critiqued by formal feedback on completion of each case. On completion of the robotic accreditation course each fellow progressed to primary surgeon with on-site proctoring. In total 143 primary/component surgeon (fellow 1 = 32 cases, fellow 2 = 47, fellow 3= 39, fellow 4= 25) procedures were performed. The majority of primary/component operator cases were rectal cancer resections (n=69), followed by colonic resections (n=48) and hernia/other (n=26).

The individual learning curves for robotic anterior resection/ULAR were recorded by all fellows prospectively over time (Figure 3). This was the number of cases taken from becoming a component surgeon (learning phase) to performing all critical steps of a robotic procedure independently (competent phase). The learning curve for robotic anterior resection/ultralow anterior resection (ULAR) for all fellows is shown (Figure 3). These curves were maintained and recorded prospectively, highlighting individual components of a procedure completed successfully and safely (green), and those not performed or that required assistance (red) by trainers and/or proctors. Individual fellow learning curves revealed independent procedure completion (learning phase into competency phase of the learning curve) at cases 11, 14, 15, and 12 respectively. Moreover, no further assistance was required (green) and cases were completed independently thereafter.

Efficacy and safety of the underlying robotic training programme was assessed by comparing 50 consecutive independently performed fellow cases with 50 consecutive consultant cases (Table 1). These cases comprised predominantly of the final robotic cases performed by the individual fellows. Patient, operative and oncological outcome parameters were analysed. There was no compromise in oncological and patient related outcomes during the introduction of the robotic training programme. There was no significance difference observed in operative time (p=0.39), blood loss (p=0.41), lymph node harvest (p=0.35), conversion rates (2%v4%), anastomotic leaks (1% v 3%) and R0 resection rates (100% v 98% colonic, 96% v 96% rectal, p=0.48) between surgical fellows and consultant trainers. Clavien Dindo (III- IV) complications between both groups were similar (10% v 6%, p=0.25) and there were no mortalities encountered

Discussion:

This study reports the efficacy and feasibility of introducing a colorectal robotic training programme within a public hospital setting without compromise to patient and operative related outcomes over a two year period. The programme utilises a two-tiered training curriculum consisting of self-directed and trainer-directed modules while adopting a parallel teaching method during operative skill acquisition. The focus of the self-direct training tier is to encourage pre-clinical knowledge and skill acquisition in a safe manner which promotes patient safety and theatre time efficiency. It has been increasingly documented that systems such as these are necessary to decrease the learning curve to proficiency status and in turn promote efficiency in skill acquisition during protected, time sensitive teaching within the operating room (20, 21). Additionally, in cases which are more complex and not routinely performed, such practices allow trainees to attain operative proficiency when fewer cases are available within a defined training time period (22). The individual components of this proposed two-tiered curriculum have been investigated in isolation over the last three decades since the inception of laparoscopic surgery (23, 24).

There has been a paucity of validated colorectal robotic training curriculums within the literature (25). This current curriculum aims is composed to promote skill acquisition which is reproducible and transferable to the OR in a safe, controlled and time effective manner. The use of surgical simulation plays a crucial role throughout this curriculum. It not only serves as a training tool but also as a credentialing instrument to ensure a particular skill set has been attained prior to progressing to a more complex step. Studies have reported significant improvements in trainee performances with simulator use, which are reliably maintained in the operative setting (26). It is felt that surgical delivery will include greater simulator based training with appropriate trainee feedback and teaching tools. The use of 3D printing and high fidelity models proving beneficial in endoscopic training which will further enable a shift away from the apprenticeship style program. The shift will require the simultaneous merging of surgical educators, relevant college bodies as well as technologies with training in the 21st century being different to current training programs. All fellows within this study were proficient in performing laparoscopic colorectal resections prior to commencing robotic training. Interestingly, proficiency of robotic skills was quick, with all fellows reaching the training set benchmarks over a relatively short period of time. Similar findings have been demonstrated in other studies examining laparoscopic surgeons transitioning to robotic surgery compared to novice trainees without laparoscopic skills (27, 28). Despite this, beginners were able to acquire basic robotic skills rapidly, demonstrating the effectiveness of simulator training in robotic surgery (29). The development of virtual reality, robotic-specific procedural tasks, such as robotic prostatectomy, have been developed which have shown improved performances equivalent to training on the robot itself (30, 31). A major proponent of this training system involves “wet lab” animal model training courses and is known to be the most important component of robotic training (32). Such courses allow safe repetition of skills that can then be transferred into clinical practice and maintained both in the short and long term (33). During these courses continuous feedback both formally and informally are provided with live case observation recommended throughout the training programme. One of the final steps of this robotic training pathway is proctorship. This involves direct supervision by an expert which is commonly mandatory by both industry and hospital management systems. Although it is time consuming and expensive, it is felt to be an important competency measure and credentialing method to ensure competency/mastery has been achieved without patient harm (34).

During the training period, all fellows participated in cart-side assisting followed by component surgery and primary operative surgery. Cart-side assisting was mandatory which involved patient set-up, port site marking, port insertion, robotic docking, camera targeting, intra-operative case assisting and de-docking. All fellows performed on average 30 cart-side assists during the training period. This ensures full understanding of how the platform functioned which promotes live case observation and intra-operative patient safety. The importance of an experienced, patient-side assistant is critical to operative time and procedural efficiency (35). All fellows progressed to becoming component and credentialed robotic console surgeons. The majority of cases performed were for rectal malignancy, followed by colonic resection and hernia/other. During these initial phases of skill acquisition, the fellow learning curve followed that of a sigmoid shape. A slow rise at the beginning, with the operator becoming accustomed to equipment in a live clinical scenario, followed by a steep rise in the curve of quick learning, reaching a plateau at which expertise had been obtained (36). An approach of parallel learning was utilised during skill acquisition, in which a procedure was divided into individual stages. These stages were performed in a stepwise manner, until the operator is deemed proficient by the trainer/proctor to progress to the next stage, allowing sequential learning (37). This is not a new concept and has been previously utilised in robotic-assisted prostatectomy training, reporting that robotic naïve surgeons can attain huge gains in skill acquisition in a short period of time (38). Furthermore, it has been shown that experienced open surgeons can perform the procedure independently after 8 – 12 robotically trained cases (39). In this study, from analysing four fellow's learning curve, procedural independence was reached at 11, 14, 15, and 12 cases for anterior resection/ULAR. It is important to note that this represents movement from the learning phase of the learning curve into competency phase of the curve. Interestingly with regards to specific task performance it was observed that skill acquisition during the abdominal phase of the resection with vessel ligation was achievable early in the learning curve. The pelvic dissection component of the procedure however, required increased case numbers to achieve competency. Other studies have reported similar findings. Bokhari et all examined three phases of the learning curve in robotic-assisted colorectal surgery, reporting completion of the learning phase after 15-25 cases (40). A systematic review in 2016 demonstrated that the mean number of cases required to be classified as completing the learning curve was 29.7 cases and classified as an expert at 39 cases (41). Within this study, each fellow was a component or primary surgeon in 25 – 47 cases, meeting similar requirements. Similarly, Nasseri et al reported transition from a learning phase into competency phase after 12 cases in robotic colorectal surgery, however mastery was not reached until after case 70 (42).

Patient, oncological and operative measures were compared between fellow and consultant-performed cases to analyse the efficacy of the training programme during the study period. There were no significant differences in any parameter measured when comparing fellow-performed versus consultant-performed procedures. Robotic colonic resections were undertaken in 163 minutes by fellows compared to 157 minutes by consultant trainers, with rectal resections accruing a time of 253 minutes for fellows and 226 mins for consultant trainers. Operative time was observed to significantly reduce as caseload increased. Such operative times are comparable if not favourable to other reported studies (43). Similarly, blood loss was comparable between both groups. To date, robotic resection has been associated with less blood loss when compared to laparoscopic and open resection (44). In this study, Yang et al report that patients undergoing robotic colonic and rectal resection had 79mls and 108mls estimated, intra-operative blood loss, reflecting similar findings between both fellows and consultant trainers. Conversion rates throughout this study was low, with one patient requiring conversion to open (2%) for adhesions in the fellow performed group and two patients (4%) in the consultant trainer group due to vessel injury and adhesions. This likely represents bias in case selection as consultants/trainers generally performed more difficult cases however it important to note the overall low rate of complications and the regard given to patient safety and outcome throughout the study.

Similarly low conversion rates have been reported in the literature highlighting the important role of robotic interventions in rectal surgery (45, 46). Oncological outcomes measured by lymph node harvest and R0 resection margins were similar across both groups and comparable with international reported studies. In addition, anastomotic leak rates and morbidity and mortality rates were not significantly different and favourable compared to published data.

There are limitations to this study. It is a single centre experience ever a relatively short period of time. In addition these findings are relatively subjective in assessing four fellows with significant potential for case selection bias and non-transferability. There was no measure of case bias selection with consultants/trainers being generally assigned more difficult cases. Despite this, the outcomes of fellow performed cases are in line with international best practises and is as a result of a structured and effective training programme (47).

Conclusion:

This study reports the feasibility and efficacy of a colorectal robotic fellowship in a public hospital setting. It documents the transition of fellows from the learning to competency phase of the learning curve within a robotic training programme. Finally, there was no compromise in patient and operative related outcomes as a result of trainee-performed cases during the study period.

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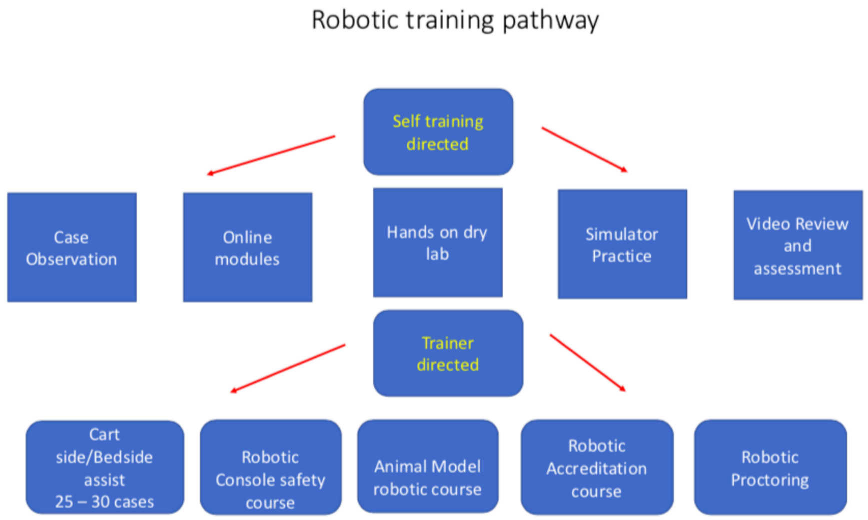

Figure 1: *Robotic colorectal surgical training programme at the Peter MacCallum Cancer centre: the training programme is composed of self-directed and trainer-directed streams.*

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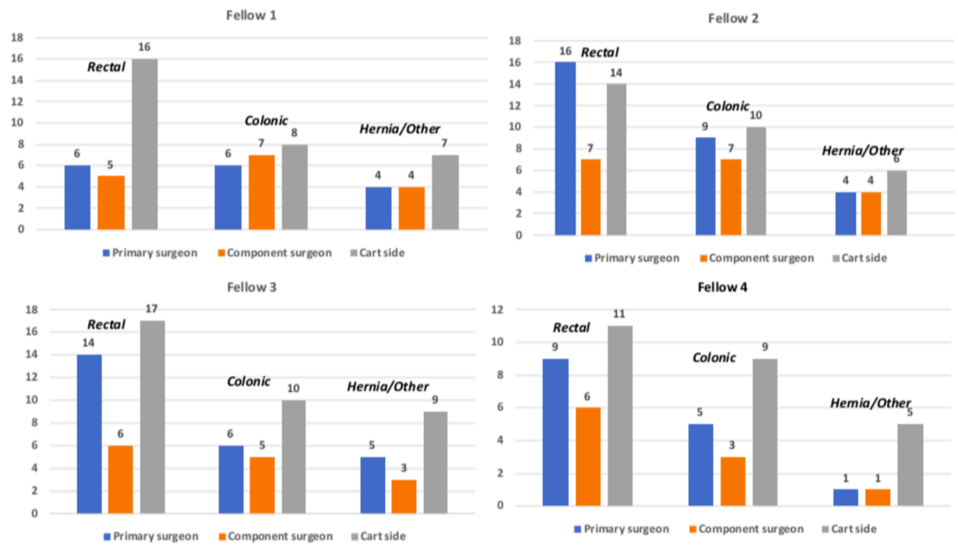
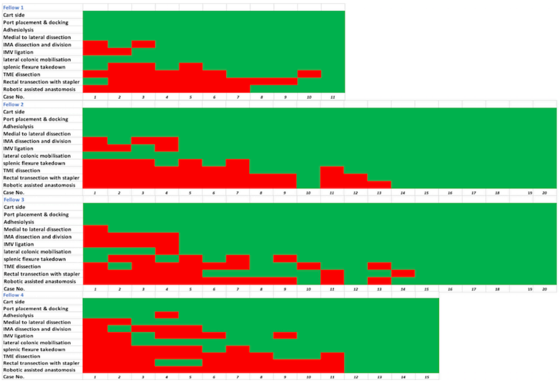


Figure 2: Robotic caseload: Fellow case procedures were recorded as primary surgeon, component surgeon and cart-side assistant. Each fellow prospectively recorded each procedure in their robotic logbook. The majority of primary/component surgeon cases carried out were rectal cancer resections (n=69) followed by colonic resections (n=46) and hernia/other (n=26).



ANS_16677_robotic rectal learning curve tiff .tiff

Colorectal Cancer resection cases (n= 100)

	Fellow (n=50)	Consultant (n=50)	Total (n=100)	P Value
Operating time (Complete S-S mins) *Colonic* *Rectal*	 163 mins 253 mins	 157 mins 226 mins	 159 mins 238 mins	 P=0.39
Blood loss (mls) *Colonic* *Rectal*	 68.6mls 110mls	 59.1mls 105mls	 62mls 107mls	 P=0.41
Average Lymph node Harvest *Colonic* *Rectal*	 20 18	 22 17	 19	 P=0.35
Completed robotically	98%	96%	97%	P=0.42
Anastomotic Leak Colonic Rectal	 2% 2%	 0% 4%	 1% 3%	P=0.26
R0 resection Negative CRM	100% (colonic) 96% (rectal)	98% (colonic) 96% (rectal)	99% 96%	P=0.48
Clavien Dindo (III-IV)	10%	6%	8%	P=0.25
Mortality	0	0	0	

Table 1: Comparative analysis of operative, oncological and patient outcomes (n=100). There was no significance difference observed in oncological, operative and patient related outcomes in fellow-performed cases compared to consultant cases (n=100).