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ORIGINAL ARTICLE

Does 3-Dimensional (3-D) visualization improve the quality of assistance during robotic radical prostatectomy?

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Abstract

Objective 3-Dimensional (3-D) visualization by the surgeon is considered to be one of the major advantages of robotic prostatectomy. We undertook this study to see if passing on this technology to the surgical assistants would improve the efficiency of their assistance.

Materials and methods The study was conducted in consecutive patients undergoing robotic radical prostatectomy by the same team, in one month at our center. A 3-D head mounted device (HMD) was used by the left and/or right assistant. Video recording from these patients were studied by a blinded observer with prior training in laparoscopic surgery for the efficiency of laparoscopic moves by the two assistants. These moves were scored on a point scoring system from 0 to 100 with 100 signifying the best possible performance.

Results After exclusions, 26 videos were available for review. Each patient had a right and left-sided assistant. The right-sided assistant had prior experience in Laparoscopic Urology, and the left-sided assistant had a relatively limited laparoscopic experience. The mean scores for the left assistant improved from 76.3 to 84.6 with the use of 3-D visualization ($p < 0.002$), while the improvement for the right assistant was from 84.1 to 86.9 (NS).

Conclusions The use of 3-D visualization possibly improves the efficiency of assistance during robotic radical prostatectomies, for the assistant with limited experience in laparoscopic surgery. Because of the high-quality 3-D vision provided, these HMDs have the potential to be used as teaching aids in the robotic lab.

Keywords Prostate cancer · Robotic radical prostatectomy · Laparoscopic skills · Laparoscopic training · 3-Dimensional visualization

Introduction

Robotic radical prostatectomy is now a very popular minimally invasive treatment option for prostate cancer. Of the various advantages provided by the robot, 3-Dimensional (3-D) visualization for the surgeon is considered to be a significant improvement over conventional laparoscopy in which, the surgeon often relies on motion parallax, and judges depth by observing the spatial relationship of objects in the field of view [1].

Studies have shown that, compared to 2-D vision, the objective performance time was significantly shorter, the procedure was felt to be easier and significantly less mistakes were made while using 3-D vision [2]. Similar observations have been made by various other authors [3–6], and the use of 3-D vision has been incorporated into the technology to aid the primary surgeon during robotic prostatectomy. Paired optical systems and cameras provide the surgeon at the console a 3-D perspective of the field. However, the assistants working on the patients' side still have to depend on 2-D images projected onto a flat-screen monitor.

Since the technology to provide a 3-D image is already available during robotic surgery, we undertook a study to see if passing this technology on to the assistants improved the efficiency of their assistance.

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Materials and methods

The study was conducted in consecutive patients undergoing robotic radical prostatectomy, by a single surgeon (A. K. T.), between 1 November and 1 December 2006. All patients underwent a standard athermal robotic-assisted laparoscopic prostatectomy [7]. As part of an ongoing training program, a physician assistant (PA) assists on the left side of the patient (left assistant) and a Fellow assists on the right side (right assistant). On the cases where the Fellow operates from the console, typically the PA moves to the right side and the main surgeon mentors the Fellow from the floor of the OR, taking over on the console as and when required.

The PA had assisted on the left side of patients in around 100 robotic prostatectomies at the time of starting the study. The Fellow had an experience of assisting or doing over 500 cases of minimally invasive urologic procedures including, stone surgeries of the upper tract, nephrectomies and pyeloplasties.

Inclusion criteria

In all cases, either or both of the assistants wore a head mounted device (HMD) for 3-D visualization. All surgeries, which were carried out by the same team comprising of the console surgeon and two assistants, and in which the assistant(s) used the 3-D system throughout the entire procedure were included in the study.

Exclusion criteria

All patients operated by a different team, or in which the assistant(s) did not use the headsets for the entire duration of the procedure, were excluded from the study. Reasons for exclusion from the study were recorded.

The Endosite 3Di 3-D system (Viking systems, La Jolla Dr., San Diego, CA, USA) consisting of binocular high-resolution video displays, one for each eye, mounted on an adjustable headband, was used. The HMD is adjustable for the inter-pupillary distance and viewing height and angle. It is connected to the video output of the Da Vinci robot and affords a 3-D view, almost identical to that provided by the robot.

The entire procedure on these patients was recorded using high-resolution digital format on tape as is routinely done in most cases. Routinely, tapes with unusual or interesting findings are labeled and stored, while the rest are sent back to a pool, to be recycled for subsequent cases. During this study, all tapes were retained and labeled as 2-D + right 3-D, 2-D + left 3-D or both 3-D, based on whether the right, left or both assistants had used the 3-D device. Thus at the time of the study, the assistants were under the impression that the 3-D device had been left for trial purposes, and were unaware that they were a part of the study.

At the end of the study, the assistants were questioned about the subjective feeling about the use of the device. The 3-D effect, visualization of structures, extra benefit because of 3-D visualization and disadvantages if any were documented on a point scale of 0–100. A plus (+) before the score indicated the positive benefit or utility, while a minus (−) before the score indicated the hindrance or negative effect of the technology.

Two months after the study was concluded, the labels on the unedited tapes were replaced with new labels carrying a code number, and these tapes were then passed on to an independent observer, not part of the operating team, and with a prior training in Laparoscopic Surgery, for review and scoring of the maneuvers. This observer was only aware of the fact that the Fellow assists on the right and the PA assists on the left. However, he was blinded to who actually used the HMD.

The efficiency of assistance was rated on a scale of 0–100 with 0 being the worst score and 100 being the best. The parameters that were studied included: (1) overall ease of instrumentation, (2) groping/semi-purposive movements, (3) overshoot of instruments, (4) clip application (average of five clips applied) and (5) scissors and cutting of sutures (average of three sutures cut). If five clip applications or three suture-cutting maneuvers were not observed, that parameter was not graded. At the end of the tape, the average performance score for the parameters was expressed as a two digit score between 0 and 100. Scoring was done on each case for the right and left assistants. All data were entered by the observer on a Microsoft Excel 2003 data sheet. After all tapes were reviewed, the data were decoded and classified under four categories: left assistant 2-D, left assistant 3-D, right assistant 2-D and right assistant 3-D.

For purposes of comparison, an identical number of patients operated immediately before the start of the study were chosen. Age, PSA, tumor stage, prostate volume, body mass index (BMI), presence of previous abdominal surgery and console times (defined as the time spent on the console) were compared between the groups. The mean values were compared using the student *t* test. All data were analyzed using the statistical software provided with Microsoft Excel 2003.

Results

After exclusions, videos from 26 patients were reviewed (Table 1). The mean age, PSA, tumor stage, BMI and presence of previous abdominal surgery were not significantly different from a group of similar patients operated just

Table 1 Demographics

	Mean ± SD (26 patients)		
	Study group	Prior patients[a]	
Age	61.1 ± 5.1	61.7 ± 4.7	NS
PSA (ng/ml)	4.9 ± 2.7	4.9 ± 2.1	NS
Prostate weight (g)	38.1 ± 11.7	43.1 ± 7.7	NS
T stage-T1c/total	18/26	20/26	NS
BMI	30.9 ± 9.1	33.2 ± 8.5	NS
Previous abdominal surgery (*N*)	3/26	5/26	NS
Operating time: console time (min)	122.3 ± 30.5	138.7 ± 68.3	NS
Excluded (*N*)	6		
Reasons for excluding			
Incomplete study	4		
Removal of 3-D due to other reasons	2		

[a] Patients operated immediately before the start of the study

before the start of the study. The console time though lower in the study group (mean difference in time of 16 min per case), was found to be not significant.

The left assistant used 3-D in 15 patients, while the right assistant used 3-D in nine patients. Six cases were excluded for various reasons. Four cases were classified as incomplete since the right-sided assistant moved to the console for part of the case. This is also the reason for the lower number of cases in which the right assistant used the 3-D HMD. In two cases, the HMD had to be removed to ensure optimal comfort of the assistant.

Efficiency of assistance

The average performance scores for the left assistant improved from a mean score of 76–84 with the use of the 3-D visualization ($p < 0.002$), while the scores for the right assistant improved from 84 to 87 and this was not significant (Table 2). A ratio of this improvement in mean scores worked out to 2.9.

The subjective evaluation by the users of the HMD showed that the overall satisfaction was scored as a +75 and +85 (Table 3). The vision provided by the device was described as "as good as that provided by the console of the robot". Though there was overall satisfaction with the device, two problems were particularly mentioned: (1) the weight of the device and (2) a restrictions of the assistants' field of vision, making it relatively more difficult to introduce, remove or exchange instruments from the instrument ports.

Discussion

Most laparoscopic surgeons use flat-screen monitors to compensate for lack of 3-D visualization by relying on motion parallax and other monocular cues, like, using spatial relationship of objects to assess depth [1]. Stereoscopic vision may allow for better 3-D orientation and judgment of distances.

With the advent of robotic surgery, systems using a paired optical system transmitting separate images are available. The Viking system used by us is one such system. Images from the telescope and twin image capturing system used by the Da Vinci robot are routinely transmitted to the laparoscopy cart as un-rendered images, for 3-D recording or for 3-D display. The cable carrying these un-rendered images can be connected to the data processing unit of the Viking system, which then converts the signals to an SVGA format for delivery to the HMD. This ensures delivery of 3-D images almost of the same quality as that on the console of the robot, to the HMD. The EndoSite 3Di system has been quoted to be approximately one-tenth as expensive as a robotic 3-D surgical system [3] and using

Table 2 Effect of 2-D and 3-D visualization on quality of assistance

	Left assistant		Right assistant	
	2-D	3-D	2-D	3-D
Number (*n*)	11	15	17	9
Overall score	76.3 ± 7.5	84.6 ± 4.2 ($p < 0.002$)	84.1 ± 5.5	86.89 ± 6.9 (*p*-NS)
Mean improvement		8.3		2.8
Ease	76.4 ± 8.9	85.6 ± 7.3	84.7 ± 6.6	88.3 ± 6.8
Groping	75.5 ± 7.9	84.7 ± 4.3	83.8 ± 6.4	86.1 ± 8.3
Overshoot	75.9 ± 3.7	84.3 ± 3.2	84.4 ± 3.1	86.7 ± 4.5
Clip appl.	77.7 ± 5.6	83.7 ± 4.1	84.7 ± 3.5	87.2 ± 3.8
Cutting	74 ± 4.5	86 ± 5.1	82.9 ± 5.1	86.1 ± 5.3

Scores: mean ± SD

Table 3 Subjective evaluation by users of the HMD

	Left assistant	Right assistant
How would you rate the vision	+90	+90
Was 3-D visualization helpful in improving your efficiency	+80	+20
What problems (if any) did you face		
Weight of the device	−50	−80
Restricting your external field of view	−25	−25
Overall satisfaction	+85	+75

Score marked on a scale of 0–100

Values in + indicates a positive effect and – indicates a negative effect

this system 24 novice laparoscopic surgeons showed that the tasks were performed faster and were considered easier as compared to the 2-D system [3].

Many other studies have found a significant improvement in the performance of tasks done with 3-D visualization: tasks done with 3-D were 32% faster and 43% more accurate, and were judged significantly easier [6]. Also, users with a normal capability for spatial perception can perform standard tasks more quickly and safely using 3-D vision and a greater benefit is apparent for more complicated surgical maneuvers [2].

The benefit of using 3-D has translated to the field of robotic surgery as well. A significant improvement in performance parameters for the task, and lower error rates were found, when operators used the stereoscopic mode of the Da Vinci robotic system [8]. Anastomotic drills were completed 65% faster [9], and when the performance was evaluated on 224 nurses without any surgical experience, time to perform the task was significantly lower in the group that used a 3-D view [10]. Independent of the biomechanical advantages of the Da Vinci Robot System, 3-D vision was found to improve performance times by 34–46% and reduce error rates by 44–66% for both inexperienced residents and advanced laparoscopic surgeons [11].

Many objective tests for comparison between 3-D and 2-D have been described. Touching a sequence of dots with a needle [5], passing a 6-0 C-1 needle consecutively through two 1-mm holes made in a thin vertical plastic wall [5], transfer tasks like bead transfer and drop [3, 11] or needle transfer [8], foam ball transfer and maneuverability using the V-box [8], needle capping, threading an eye, knot tying [11], rope passing [8], suturing [4, 8] and cutting tasks [4] have all been used as standardized tests. Basic technical surgical skills recorded electronically in modules selected in five commercially available computer-based simulators have also been used to measure surgeon proficiency, and the proficiency levels for training courses can now be specified objectively [12]. An endoscopic surgical skill qualification (ESSQ) system has also been described, and this attempts to objectively assess the ability to complete common laparoscopic surgeries by the surgeon. Skill assessment is performed by evaluating an unedited videotape of the surgeon completing the entire procedure in double-blinded fashion [13].

Many of the above-mentioned examination methods may be useful to objectively measure basic or minimal skills [13]. However, competence in highly complicated procedures is more difficult to measure by a simple evaluation of basic skills [13]. Various factors render comparison between groups difficult. Patient factors include differences in body habitus, presence of adhesions or excessive bleeding or oozing. Disease status may necessitate modifications in the procedure, and difficult dissection planes may require the surgeon to do a slower dissection. Surgeon factors like individual learning curves and the level of knowledge of local anatomy also make comparisons difficult.

We attempted to measure differences in the ease of laparoscopic maneuvers between groups by studying unedited video tapes recorded on patients in the two groups. We do agree that interpretation of the tapes have a component of subjectivity and scores may be subject to an inter-observer variation, and these are the major limitations of our study. Ideally, more than one reviewer could have screened the videos, and an average of scores could have been used. However, since each of the videos would have had to be reviewed from the start of the dissection till the end of the procedure, and still the element of subjectivity could not have been excluded completely, time constraints did not permit the use of more than one reviewer.

We attempted to eliminate some of the variations by studying a very similar group of patients undergoing the same surgery, by the same team, and having the assessment of the procedure performed by the same blinded observer. We further attempted to minimize the subjectivity component using five parameters, and using a scale of 0–100. Since the assistants were unaware that they were a part of the study, we feel that any improvement in performance attributable to the effect of undergoing observation might have been eliminated.

We found that the use of 3-D visualization improves the assistants' efficiency during robotic prostatectomy but this effect maybe less pronounced for the laparoscopically experienced surgeon who has learned to adjust for lack of 3-D vision by using other monocular cues. This device may thus be more useful for the assistant with limited laparoscopic skills during robotic prostatectomy. We feel that its utility as a teaching aid for prospective robotic surgeons, medical students and nurses needs to be explored. Though more trials, using larger number of patients will be required in order to recommend its routine use for assistants of robotic surgery, there maybe a definite role for the use of this device as a teaching aid in robotic labs.

Conclusions

The use of 3-D visualization seems to improve the efficiency of assistance during robotic radical prostatectomies, particularly for the assistant with limited experience in laparoscopic surgery. The vision provided by the HMD is very similar to that of the console of the robot and this has implications for the use of this technology as a remarkable teaching aid in addition to being used by assistants. More trials proving its benefit are indicated in order to justify its routine use by assistants of robotic surgeries.

Conflict of interest statement There is no conflict of interest.

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