Review Article

3 D Laparoscopy: A Review

Sharda R.[1], Sharda P.[2]

[1]Dr. Rajeev Sharda, Consultant Laproscopic Surgeon, [2]Dr. Pratibha Sharda, Consultant Gynaecologist, Sharda Hospital, Bhopal, India.

Corresponding Author: Dr. Rajeev Sharda, Consultant Laproscopic Surgeon, Sharda Hospital, Bhopal, India. E-mail: shardarajeev@ymail.com

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Abstract

Background: Restricted depth perception in laparoscopy with two-dimensional imaging has been reported to be a major disadvantage of minimally invasive procedures. Three-dimensional imaging have been available for almost 2 years and are slowly being integrated into endoscopic surgery. **Methods:** A systematic search of the literature was conducted to identify randomized controlled trials that compared 3D with 2D laparoscopy. Some review articles were also searched. No language or year of publication restrictions was applied. Data extracted were cohort size and characteristics, skill trained or operation performed, instrument used, outcome measures, and conclusions. Two independent authors performed the search and data extraction. **Results:** Many articles were screened for eligibility, and RCTs were included in the review. Time was used as an outcome measure in all of the trials, and number of errors was used in 19 out of 16 trials. Seven out of 11 trials (71%) showed a reduction in performance time, and 10 out of 16 (63%) showed a significant reduction in error when using 3D compared to 2D. **Conclusions:** This study aims to show that 3D technology in laparoscopy promises to be an indispensable tool. The feasibility and safety of this surgical innovation has been shown. Overall, 3D laparoscopy appears to improve speed and reduce the number of performance errors when compared to 2D laparoscopy. Most studies to date assessed 3D laparoscopy in simulated settings, and the impact of 3D laparoscopy on clinical outcomes has yet to be examined.

Keywords: Laparoscopy, Three-dimensional imaging, Laparoscopic training, Surgical skills

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Introduction

Laparoscopic surgery is widely used, and results in accelerated patient recovery time and hospital stay were compared with laparotomy. However, laparoscopic surgery is more challenging compared with open surgery, in part because surgeons must operate in a three-dimensional (3D) space through a two-dimensional (2D) projection on a monitor, which results in loss of depth perception. To counter this problem, 3D imaging for laparoscopy was developed. A systematic review of the literature was performed to assess the effect of 3D laparoscopy.

Equipment

3D HD video system consisting of a dual-channel laparoscope, a stereoscopic camera, a camera controller with two separate outputs and a wavelength multiplex stereoscopic monitor. Learning curve was 3 to 6 months in almost all studies.

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Discussion

Recent findings with the new-generation 3D high-definition laparoscopic vision systems (LVSs), operation time and learning period are reduced and procedural error margin is decreased. New-generation 3D high-definition LVSs enable to reduce operation time both for novice and experienced surgeons. Headache, eye fatigue or nausea reported with first-generation systems are not different than two-dimensional (2D) LVSs. The system's being more expensive, having the obligation to wear glasses, big and heavy camera probe in some of the devices are accounted for negative aspects of the system that need to be improved.

Summary Depth loss in tissues in 2D LVSs and associated adverse events can be eliminated with 3D high-definition LVSs. By virtue of faster learning curve, shorter operation time, reduced error margin and lack of side-effects reported by surgeons with first-generation systems, 3D LVSs seem to be a strong competition to classical laparoscopic imaging systems.

Thanks to technological advancements, using lighter and smaller cameras and monitors without glasses is in the near future.

[A] World Scenario- Hanna GB, Shimi SM et al did randomised study of influence of two-dimensional versus three-dimensional imaging on performance of laparoscopic cholecystectomy. The operations were done by four specialist registrars as part of their higher surgical training. 60 operations were randomised for execution by either two-dimensional or three-dimensional imaging display (30 by each method).

The degree of difficulty of the operation was graded by a consultant surgeon on a standard grading system. The primary endpoints were execution time and the errors made during the procedure. The scores for visual strain, headache, and facial discomfort were higher with the three-dimensional system.With the current technology, three-dimensional systems based on sequential imaging show no advantage over two-dimensional systems in the conduct of laparoscopic cholecystectomy [1].

Chan AC, Chung SC et al did Comparison of two-dimensional vs three-dimensional camera systems in laparoscopic surgery. They prospectively studied two groups of surgeons who performed a designated standardized laparoscopic task using a two-dimensional camera systemvs a three-dimensional camera systems and compared their time performances. The results suggested that only experience in laparoscopic surgery had significant effect on individual's performance. They could not demonstrate any superiority of the 3D system over the 2D system. However, two-thirds of the surgeons commented that the depth perception did improve. So they concluded that with further refinement of the technology, the 3D system may improve its potential in laparoscopic surgery [2].

Mcdougall EM, Sobleet al discussed about Comparison of three-dimensional and two-dimensional laparoscopic video systems. They found that the limitations of two-dimensional (2D) video may be overcome by the recent introduction of the three-dimensional (3D) laparoscope and video system. The time needed to complete each technique was recorded and compared using nonparametric analysis. The participants' subjective evaluation of the 3D system was also analyzed. Three-dimensional video did not significantly improve the surgeons' ability to perform laparoscopic dissection of the kidney, securing the renal vessels, or laparoscopic suturing and knot-tying. Surgeons felt that the 3D system did not improve vision or perceived surgical performance sufficiently to justify an expense greater than that of the 2D systems now available. Compared with the standard 2D camera system, the currently available 3D video system does not hasten the laparoscopic dissection of tissues or the performance of advanced technical maneuvers such as laparoscopic suturing and knot-tying by experienced laparoscopists [3].

Kong SH, Oh BM et al did Comparison of two-and three-dimensional camera systems in laparoscopic performance, Jones DB, Brewer JD also did similar study onthe influence of three-dimensional video systems on laparoscopic task performance. Alaraimi B, El Bakbak W etaldida randomized prospective study comparing acquisition of laparoscopic skills in three-dimensional(3D) vs. two-dimensional (2D) laparoscopy. Honeck P, Wendtet al dida study and inferred that three-dimensional laparoscopic imaging improves surgical performance on standardized ex-vivo laparoscopic tasks. Votanopoulos K, Brunicardi F et al evaluated the impact Impact of three-dimensional vision in laparoscopic training [4-8].

Lusch A, Bucur PL alsoEvaluated the impact of three-dimensional vision on laparoscopic performance 3D laparoscopic camera equipment results in a significant improvement in depth perception, spatial location, and precision of surgical performance compared with the conventional 2D camera equipment. With this improved quality of vision, even expert laparoscopic surgeons may benefit from 3D imaging [9].

Mueller MD, Camartin C et alstudy was designed to compare conventional laparoscopy with three-dimensional (3-D) laparoscopy. Thirty candidates, 20 inexperienced and 10 experienced in operative laparoscopy, executed standardized exercises on a pelvitrainer. The candidates were randomized to two groups. Group A executed the exercises first with the conventional and then with the three-dimensional system. Group B accomplished the exercises in the reverse sequence.

At the end of the exercises, the candidates answered specific questions about the two systems. There was no statistically significant difference from group B. When analyzed in a standardized fashion, 3-D laparoscopy does not have any significant advantages over conventional laparoscopy [10]. Contrary to above study, the study of Birkett DH, Josephs LG was set up to compare three-dimensional imaging of a new three-

dimensional laparoscope with two-dimensional imaging in the inanimate and clinical settings. In the clinical setting the laparoscope was used in a total of 50 different laparoscopic operations. It provided excellent depth perception, definition, and resolution. The relationships of structures were more easily defined, and instrument manipulation was easier, doing away with the need for "touch and feel" to determine instrument position. Three-D imaging may reduce operative time for laparoscopic procedures, particularly the more complicated operations [11].

Alaraimi B, El Bakbak W et al in arandomized prospective study comparing acquisition of laparoscopic skills in three-dimensional (3D) vs. two-dimensional (2D) laparoscopyusing Fundamentals of Laparoscopic Surgery (FLS) tasks.Fifty-six novices with no uncorrected visual problems were randomly allocated to 2D and 3D groups. All candidates practiced FLS tasks on a box trainer until they achieved proficiency. Their performance was assessed by considering completion time, number of repetitions, and number of errors following the validated FLS proficiency criteria. Stereoscopic vision improved accuracy in laparoscopic skills for novices, which was manifested in reduced numbers of repetitions and errors. However, it does not affect the global performance time across all tasks [12].

In a systematic review by Sørensen SM, Savran M Mcomparing Three-dimensional versus two-dimensional vision in laparoscopy. Three hundred and forty articles were screened for eligibility, and 31 RCTs were included in the review. Three trials were carried out in a clinical setting, and 28 trials used a simulated setting.

Time was used as an outcome measure in all of the trials, and number of errors was used in 19 out of 31 trials. Twenty-two out of 31 trials (71%) showed a reduction in performance time, and 12 out of 19 (63%) showed a significant reduction in error when using 3D compared to 2D. Overall, 3D laparoscopy appears to improve speed and reduce the number of performance errors when compared to 2D laparoscopy. Most studies to date assessed 3D laparoscopy in simulated settings, and the impact of 3D laparoscopy on clinical outcomes has yet to be examined [13]. Surgical task efficiency in standardized phantom tasks was done by Storz P, Buess GF et al. The aim of this studywas to evaluate users' performances in standardized surgical phantom model tasks using 3D HD visualization compared with 2D HD regarding precision and working speed.In four of the five tasks the study participants made fewer mistakes in 3D than in 2D vision. In four of the tasks they needed significantly more time in the 2D mode. Both the student group and the surgeon group showed similarly improved performance, while the surgeon group additionally saved more time on difficult tasks.This study shows that 3D HD using a state-of-the-art 3D monitor permits superior task efficiency, even as compared with the latest 2D HD video systems [14].

Kunert W, Storz P et al tried how to get maximum benefit from 3D vision. 3D laparoscopy is a step toward advanced surgical navigation. Shutter-based 3D video systems failed to become established in the operating room in the late 1990s. To strengthen the starting conditions of the new 3D technology using better monitors and high definition, the authors give suggestions for its practical use in the clinical routine.

But first they list the characteristics of single-channeled and bichanneled 3D laparoscopes and describe stereoscopic terms such as "comfort zone," "stereoscopic window," and "near-point distance." The authors believe it would be helpful to have the 3D pioneers assemble and share their experiences with these suggestions [15].

A prospective randomized experimental evaluation of three-dimensional imaging in laparoscopy was done by Peitgen K, Walz MV. They evaluated the effects of three-dimensional imaging on surgical performance and its influence on surgeons at different experience levels in a prospective randomized trial.

Three- dimensional imaging significantly improves performance (speed and accuracy) regardless of previous laparoscopic experience. Thus, three-dimensional imaging may further improve the safety aspect of minimally invasive surgery [16]. Tanagho YS, Andriole GL compared 2D versus 3D visualization and itsimpact on laparoscopic proficiency using the fundamentals of laparoscopic surgery skill set.

Subjective measures of efficiency and accuracy also favored 3D visualization. The advantage of 3D vision persisted independent of participants' level of technical expertise (novice versus intermediate/expert). There were no differences in reported side effects between the two visual modalities. Overall, 87.9% of participants preferred 3D visualization. Three-dimensional vision appears to greatly enhance laparoscopic proficiency based on objective and subjective measures.In our experience, 3D visualization produced no more eye strain, headaches, or other side effects than 2D visualization. Participants over whelmingly preferred 3D visualization [17].

[B] Indian Scenario- Sinha R, Sundaram M, Raje S et al studied 3D laparoscopy: technique and initial experience in 451 cases. This study aims to show that 3D technology in laparoscopy promises to be an indispensable tool. The feasibility and safety of this surgical innovation has been shown. The tactile feedback is retained; the precision, accuracy, and depth perception are remarkable. The learning curve is short (less than five cases). The initial investment and recurring cost are low compared to robotic-assisted laparoscopies. The time taken for surgery as well as morcellation is less than in 2D HD laparoscopy. The possibility of complications may be less also [18]. Supe ANin their two articles, one onlaparoscopic training in India andneed for criterion-based training and objective assessment of surgical skills and another on ergonomics in laparoscopic surgery. They inferred that laparoscopic surgery provides patients with less painful surgery but is more demanding for the surgeon.

The increased technological complexity and sometimes poorly adapted equipment have led to increased complaints of surgeon fatigue and discomfort during laparoscopic surgery. Ergonomic integration and suitable laparoscopic operating room environment are essential to improve efficiency, safety, and comfort for the operating team. Understanding ergonomics can not only make life of surgeon comfortable in the operating room but also reduce physical strains on surgeon [19,20].

Desai M, Chabraetal on the other hand wrote on emergence ofrobotic surgery and its readiness for prime time in India. Robotic surgery with its bundled advantages is still in its burgeoning phase, the best of which is yet to come. India is readily accepting this robotic surgical innovation, the use of which is on a continuous rise, with the number of robotic platforms coming up in increasing numbers in many tertiary care Indian centres and a corresponding increase in demand of the same by the patients as well; thereby aptly fulfilling the economics of 'demand and supply'[21]. While Usta TA, Gundogduet al again emphasized the role ofthree-dimensional high-definition laparoscopic surgery for gynaecology. This article reviews the potential benefits and disadvantages of new three-dimensional (3D) high-definition laparoscopic surgery for gynaecology. Recent findings with the new-generation 3D high-definition laparoscopic vision systems (LVSs), operation time and learning period are reduced and procedural error margin is decreased. New-generation 3D high-definition LVSs enable to reduce operation time both for novice and experienced surgeons. By virtue of faster learning curve, shorter operation time, reduced error margin and lack of side-effects reported by surgeons with first-generation systems, 3D LVSs seem to be a strong competition to classical laparoscopic imaging systems. Thanks to technological advancements, using lighter and smaller cameras and monitors without glasses is in the near future [22].

Conclusion

It provided excellent depth perception, definition, and resolution. The relationships of structures were more easily defined, and instrument manipulation was easier, doing away with the need for "touch and feel" to determine instrument position. Three-D imaging made cannulation of the cystic duct for cholangiography or with a flexible choledochoscope easier.

Three-dimensional vision appears to greatly enhance laparoscopic proficiency based on objective and subjective measures. In our experience, 3D visualization produced no more eye strain, headaches, or other side effects than 2D visualization. Participants overwhelm-mingly preferred 3D visualization.

What this study adds to existing knowledge?

Three-D imaging provided excellent depth perception, definition, and resolution. The relationships of structures were more easily defined, and instrument manipulation was easier, doing away with the need for "touch and feel" to determine instrument position.

Author's contribution

Dr. Rajeev Sharda: Concept and design of the study.
Dr. Pratibha Sharda: Data collection and references

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