Medical and Research Publications
International Open Access

Research Article **Journal of MAR Oncology (Volume 5 Issue 1)**

Initial Experience with an Integrated 4K and Three-Dimensional (3D) High Definition (HD) Endoscopy for Advanced Oncological Abdomino-Thoracic Surgeries

Nusrath, Syed *[1], Ameer Zeeba Usofi [2], Iyer R Rajagopalan [3], Patnaik Sujit Chyau [4], Shukla Srijan [5], Saksena Ajesh Raj [6], Raju KVVN [7], Thammineedi Subramaneshwar Rao [8]

1. Department of Surgical Oncology, Basavatarakam Indo American Cancer Hospital and Research Institute, Hyderabad, Telangana, INDIA.

2. Department of Surgical Oncology, Kokilaben Dhirubhai Ambani Hospital, Mumbai.

3. Department of Surgical Oncology, Basavatarakam Indo American Cancer Hospital and Research Institute, Hyderabad, Telangana, INDIA.

4. Department of Surgical Oncology, Basavatarakam Indo American Cancer Hospital and Research Institute, Hyderabad, Telangana, INDIA.

5. Department of Surgical Oncology, Basavatarakam Indo American Cancer Hospital and Research Institute, Hyderabad, Telangana, INDIA.

6. Department of Surgical Oncology, Apollo Hospital, Jubilee Hills, Hyderabad.

7. Department of Surgical Oncology, Basavatarakam Indo American Cancer Hospital and Research Institute, Hyderabad, Telangana, INDIA.

8. Department of Surgical Oncology, Basavatarakam Indo American Cancer Hospital and Research Institute, Hyderabad, Telangana, INDIA.

Corresponding Author: Nusrath, Syed, MS, DNB (General Surgery, DNB (Surgical Oncology) Department of Surgical Oncology, Basavatarakam Indo American Cancer Hospital and Research Institute, Hyderabad, Telangana, INDIA.

Received Date: December 05, 2022

Published Date: December 15, 2022

Abstract

Background *This study reports our preliminary experience with the safety and feasibility of thoracic and laparoscopic surgeries with the IMAGE1 S™ RUBINA™ (Karl Storz, Tuttlingen, Germany), the latest 3D laparo-endoscope integrated with 4K, and near infrared – indocyanine green imaging (NIR-ICG).*

Materials *Thirteen patients undergoing various advanced oncological thoracic and laparoscopic operations were included. Three operating surgeons rated their experiences by filling out a questionnaire on this system. The clarity, depth of perceptions, lack of eye strain and headache, hand-eye coordination, dexterity, the overall experience of surgery, operative time, and surgical complications were noted..*

Results *An enhanced characterization of tissue planes with a high-resolution display, with additional depth perception made the dissection of tissue planes precise. The quality of NIR-ICG imaging was superb. All the operating surgeons gave a score of 1 on a scale of 1 to 5 from excellent* ***(****Score 1****)*** *to poor* ***(****Score 5****)*** *for all 6 parameters, including clarity, depth of perceptions, lack of eye strain, hand-eye coordination, dexterity, and overall experience of the surgery.*

Conclusions *Addition of a 4K high definition system to three-dimensional endoscopy augments high resolution of the surgical field with greater anatomical differentiation, improved depth of perception, enhances the visibility in advanced thoraco-abdominal surgeries, and is associated with higher accuracy as well as a shorter learning curve. Larger studies are required to confirm our findings.*

Introduction

Since its inception, laparoscopic surgery has heralded a new revolution in clinical practice concerning lesser postoperative pain, lesser ICU, and hospital stay with early ambulation, and early return to work compared to open surgery (1). Developments of high-definition (HD) laparoscopes, advanced instruments, and articulating staplers improved the feasibility and safety of laparoscopic procedures. However, minimally access surgery (MAS) procedures are more challenging than the corresponding open procedures in that, they demand different psychomotor skills, such as disparate movements of the instruments secured at the level of the abdominal wall (fulcrum effect) with differing haptic competencies (2). In the 2D depiction, depth perception can no longer be assessed via stereopsis or through the oculomotor system, allowing the compensatory visual mechanism to play (3). Hence the surgeons depend on subjective spatial depth cues to derive the indirect 3D information.

Consequently, the introduction of 3D laparoscopic systems improved hand-eye coordination stereopsis, with shorter learning curves (4,5,6). Recently, 4K ultra-high definition (UHD) 2D endoscopic systems have been introduced into clinical practice with four times the resolution of high definition (HD), resulting in more significant anatomical differentiation of the surgical field (7). Even this 2D high-definition system lacks spatial orientation and does not provide depth perception; the major constraints of two-dimensional (2D) laparoscopy with a possible risk of surgical strain, errors, and longer operative time. The loss of spatial depth information in a two-dimensional vision system was compensated by surgeon experience and the ability of the human brain to interpret spatial depth.

This paper describes the utility and feasibility of high-definition 3D laparoscopy with 4K integration with near-infrared- indocyanine green (NIR-ICG) in various thoracoabdominal surgeries using the recently launched IMAGE1 S™ RUBINA™ (Karl Storz, Tuttlingen, Germany) that delivers the advantages of 3D with 4K resolution. The use of this new generation three-dimensional (3D) HD with a 4K laparoscopic system combines different elements: improved quality of vision (3D vision) with tactile feedback and proprioception (from laparoscopy), and high definition (in 4K resolution), resulting in higher anatomical differentiation of the surgical field. These elements could reduce the learning curve with improved surgical precision, resulting in better surgical performance.

Methods

This is a retrospective study of 13 patients undergoing surgery by minimally access technique for proven carcinomas of various subsites using the Image1S™ RUBINA from Karl Storz in November 2021 at Basavatarakam Indo American Cancer Hospital and Research Institute, Hyderabad, Telangana, India. Three surgeons with a varying experience of 2-3 years in minimal access surgery, operated on all cases under the guidance of 2 senior surgeons. All the 3 operating surgeons were well-versed in the function of high-definition 2D, 3D, and 4K systems available at the institute. This study describes the intraoperative experience in patients undergoing surgery using this high-definition system.

The surgeons were provided with a questionnaire wherein they were required to grade the operating system on a scale of 1 to 5, from excellent **(**Score 1**)** to poor **(**Score 5**)**, based on six parameters. Each parameter includes clarity, depth of perceptions, lack of eye strain, hand-eye coordination, dexterity, and overall experience of the surgery.

Image1S™ RUBINA- The Image1S™ RUBINA, the latest HD system from Karl Storz, combines the 4K and 3D imaging technology with fluorescence NIR-ICG imaging in the infrared band. The technology provides increased resolution, excellent image quality in white light and NIR/ICG modes, and a natural color rendition. The camera chip enables 4K white light and 4K NIR/ICG modes. NIR/ICG offers three modes; the overlay mode, the intensity map mode, and the monochromatic mode incorporated in one system by the OPAL1 NIR/ICG technology. Operative set is shown in figure no 1.

In overlay mode, the regular white light image is superimposed with NIR-ICG fluorescent green images. In monochromatic mode, the NIR/ICG signal is displayed in white on a black background to achieve the most significant possible differentiation. The Intensity Map mode displays the intensity of the NIR/ICG signal using a color scale in an overlay image. The standard Laser free LED light source provides both the near-infrared and white light. The fifty-five-inch monitor compatible with 4K/3D imaging comes with a screen resolution of 3840 x 2160 in 16:9 image format **(**Panel A, Figure 2**)**. High-resolution video-endoscope TIPCAM® **(**Karl Storz, Tuttlingen, Germany**)** comes with a 30- and 0-degree telescopes, 10 mm diameter, 32 cm length, autoclavable, freely programmable camera head buttons, including video connecting cable, for use with IMAGE1 S CONNECT® II and IMAGE1 S™ 4U-LINK **(**Panel B, Figure 2**)**. Fogless, passive polarized glasses and 3D circular polarized clip-on glasses come for use with a 3D monitor **(**Figure 3**)**. Three dimensional 4K resolution image was achieved by 55 inches 3D 4K monitor **(**Panel B, Figure 2**)** and viewed with polarized glasses by the surgeons and assistants **(**Figure 4**)**.

Figure 1: Showing operative setup with 3D-4K System **(**Rubina**)**®

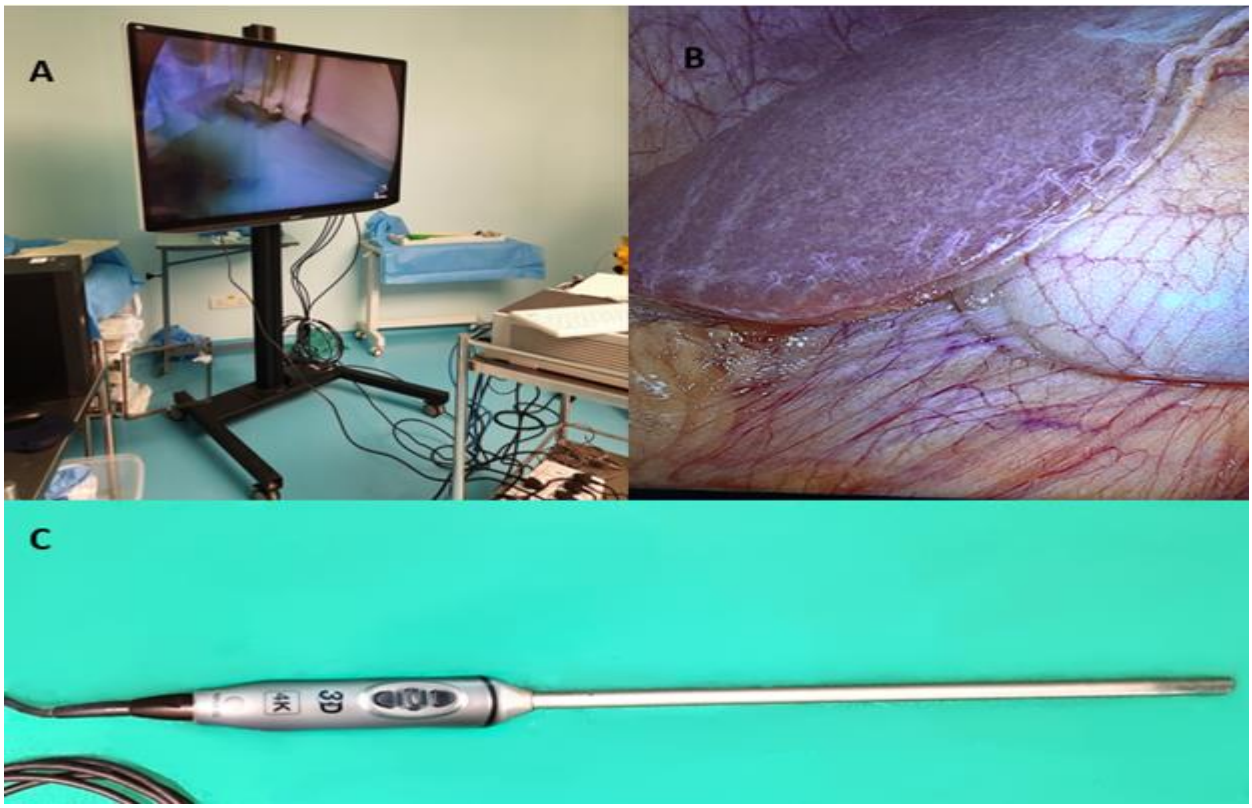

Figure 2: A. Showing Image1S™ RUBINA TM **B**. Intraoperative 3D images captured from the screen showing gall bladder and liver. **C**. High-resolution 30 degrees video-endoscope TIPCAM®1 RUBINA

Figure 3: Shows 3D circularly polarized clip-on glasses **(**above panel**)** and polarization glasses **(**lower panel**)** for use with a 3D monitor

Figure 4: Intraoperative 4k resolution image showing supra-azygous in dissection patient undergoing transthoracic esophagectomy.

Results

Thirteen patients underwent various thoracic and laparoscopic surgeries for cancer by IMAGE1 S™ RUBINA™ were included. The procedures performed were: four thoraco-laparoscopic esophagectomies, 3 colectomies, 3 hysterectomies, 1 radical gastrectomy, and 2 right upper lobectomies **(**for lung cancer**)**. There were 2 conversions, one was due to intrathoracic bleeding in the thorax during lung surgery and one due to locally advanced malignancy necessitating open surgery. The quality of NIR-ICG imaging was superb **(**Figure 5**)**. ICG thoracic duct lymphography was done in 3 patients during thoracic esophageal mobilization for carcinoma esophagus and two other patients underwent ICG sentinel nodal biopsy during surgery for endometrial cancer.

All the cases were operated on by 3 surgeons having 2-3 years of expertise in minimally invasive surgery under the supervision of 2 senior surgeons. Greater anatomical definition with stronger stereopsis enabled enhanced hand-eye coordination and dexterity. Intraoperative assessment and operative maneuvering with a high resolution made dissection of tissue planes precise. A 4K UHD resolution added to the surgical

performance offered by 3D by making the depth perception signals clearer, providing higher resolution, and adding to finer anatomical details of the surgical field **(**Figure 4**)**. The expanded color spectrum of 4K UHD provided a much wider color scale allowing appreciation of subtle differences in red and yellow colors helped in distinguishing even minor arteries and veins vividly as well as other finer tissue details in the surgical field **(**Figure 4**)** All the 3 operating surgeons felt the large, 55-inch ultra-high-definition display with four times higher resolution than traditional Full HD laparoscopic systems gave the surgeon an immersive experience where a surgeon feels that he/she is stepping inside the patient's body and operating.

All the 3 surgeons gave a score of 1 on a scale of 1 to 5 ranging from excellent **(**Score 1**)** to poor **(**Score 5**)** for all 6 parameters including clarity, depth of perceptions, lack of eye strain, hand-eye coordination dexterity, and overall experience of surgery. There was good hand-eye coordination with no eye strain or headache even in prolonged and complex procedures. The overall experience of surgery was described as very pleasant by all the surgeons.

Figure 5: Depicts the high-resolution image of intraoperative fluorescent cholangiography demonstrating right and left hepatic ducts, common hepatic, bile duct and cystic duct. Mild enhancement of gall bladder is also seen.

Discussion

Stereopsis is the perception of depth that arises from comparing images projected to two laterally separated eyes. Laparoscopically assisted surgery is associated with an extended and difficult learning curve compared to the corresponding open procedure, most important due to the loss of stereoscopic depth perception through the 2D representation of the surgical field.

To address this difficulty, laparoscopic 3D systems have been introduced to facilitate the learning and implementation of minimal access surgery **(**MAS**)** procedures. The 2D laparoscopic system consists of a single camera **(**monoscopic**)**, which is the primary reason for lack of depth of perception. On the other hand, 3D laparoscopy contains two side-by-side cameras **(**stereoscopic**)**. Images from these two different cameras pass through an eyeglass in which each eyepiece corresponds to one camera. Finally, images are filtered and received as one; this leads to an increase in depth of perception. Increased depth of perception is associated with higher accuracy and speed in performance and translate into a shorter learning curve.

In most commercially available 3D systems, users wear lightweight glasses that polarize alternate horizontal rows of pixels corresponding to the right- and left-eye images. Numerous studies published in recent years, both in experimental and clinical settings, suggest that 3D systems present several potential benefits to surgeons, trainees, and patients compared to the 2D system **(**8**)**. Of few studies involving experienced surgeons evaluating 3D HD systems against 2D HD laparoscopic cholecystectomy, Sahu et al. noted a 14 minute shorter operative time with 3D **(**9**)**. Bilgen et al. had a 9 minute shorter time with 3D **(**10**)**, while Tung et al. noticed no difference **(**11**)**. However, these were small underpowered studies. Koppatz et al. reported a large 3D HD versus 2D HD laparoscopic cholecystectomy study, with over 100 participants in each arm **(**12**)**. They observed no significant difference in complication rates or operative times between 3D and 2D arms, including subgroup analysis for the surgical experience. In 2018 European Association of Endoscopic Surgery **(**EAES**)** recommended 3D vision in laparoscopy over a 2D HD system to reduce the operative time **(**13**)**.

Recently, 4K UHD 2D laparoscopic systems have been introduced into clinical practice providing greater anatomical differentiation of the surgical field. 4K UHD 2D technologies were thought to provide stronger monocular depth perception cues and improve surgical performance concerning superior accuracy and dexterity than 2D HD representation. A large, 55-inch ultrahigh definition of 4K display gives four times more resolution than traditional HD laparoscopic systems giving the operating surgeon an immersive experience with viewing distances closer than ever before. The expanded color spectrum in 4K UHD

provides a much broader color scale than the conventional HD system, allowing the appreciation of more subtle differences in red and yellow colors, which may help distinguish even minor arteries and veins and other fine details in the surgical field.

3D laparoscopy was superior to a 4k HD system in toolbox training systems. A randomized controlled trial **(**RCT**)** by Thomaschewski et al. compared a laparoscopic 4K UHD 2D vs. a laparoscopic 3D HD system for differences in learning MIS skills using the Lübeck Toolbox **(**LTB**)** video box trainer, indicated that MIS basic skills can be learned quicker using a 3D HD system vs. a 4K UHD 2D system. However, for MIS tasks in confined spaces, the learning speed with 4K UHD 2D imaging was comparable to a 3D HD system **(**14**)**. Similarly, Harada et al. also reported that surgical MIS skills were equivalent for 4K UHD 2D and 3D HD in knotting and suturing in narrow spaces, while 3D was superior in more open spaces **(**15**)**.

However, 3D laparoscopy could not prove conclusive superiority over the 4K HD system in clinical practice. In an RCT comparing laparoscopic cholecystectomy by 3D and 4K system, 3D HD laparoscopic system did not reduce operative time or error scores during laparoscopic cholecystectomy compared with a new 4K imaging system **(**16**)**.

The Image1S™ RUBINA TM, the latest HD system from Karl Storz, combines the 4K and 3D imaging technology with fluorescence NIR-ICG imaging in the infrared band. Greater anatomical definition with stronger stereopsis enabled enhanced hand-eye coordination and dexterity with this system. A 4K UHD with 3D improved the depth of perception, providing higher resolution, adding finer anatomical details of the surgical field with dissection of tissue planes precise and bloodless (17). The expanded color spectrum makes appreciation of minor arteries and veins and other finer tissue details more explicit in the surgical field giving an immersive experience to surgeon. All the parameters like clarity, depth of perceptions, lack of eye strain, hand-eye coordination, dexterity, and overall surgery experience were greatly appreciated by surgeons in the study. There was perfect eye coordination with no eye strain and headache with prolonged and complex surgeries with an overall experience of surgery very pleasant described by all surgeons.

Since there is limited information on this system, we feel a 4K UHD resolution could further improve surgical performance offered by 3D by making the depth perception cues clearer, providing greater anatomical differentiation of the surgical field with a much broader color scale **(**17**)**.

The limitations to this study were that the surgeons were not screened for stereo acuity, visual acuity, and color vision. Small numbers, single institutional study, and single-arm were additional deficiencies of the study. Nevertheless, our study can serve as a base for future randomized control trials evaluating 3D vs. 4K vs. integrated 3D and 4K systems.

Conclusion

4K UHD resolution could further improve surgical performance offered by 3D by making the depth perception cues clearer, providing greater anatomical differentiation of the surgical field with much wider color scale

References

1. Veldkamp R. COlon cancer Laparoscopic or Open Resection Study Group (COLOR): Laparoscopic surgery versus open surgery for colon cancer: short-term outcomes of a randomised trial. Lancet Oncol. 2005;6:477-84.

2. Berguer R, Smith WD, Chung YH. Performing laparoscopic surgery is significantly more stressful for the surgeon than open surgery. Surgical endoscopy. 2001 Oct;15(10):1204-7

3. Shah J, Buckley D, Frisby J, Darzi A. Depth cue reliance in surgeons and medical students. Surgical Endoscopy and Other Interventional Techniques. 2003 Sep;17(9):1472-4

4. Roach VA, Mistry MR, Wilson TD. Spatial visualization ability and laparoscopic skills in novice learners: Evaluating stereoscopic versus monoscopic visualizations. Anatomical sciences education. 2014 Jul 8;7(4):295-301,

5. Alaraimi B, El Bakbak W, Sarker S, Makkiyah S, Al-Marzouq A, Goriparthi R, Bouhelal A, Quan V, Patel B. A randomized prospective study comparing acquisition of laparoscopic skills in three-dimensional (3D) vs. two-dimensional (2D) laparoscopy. World journal of surgery. 2014 Nov;38(11):2746-52,

6. Sørensen SM, Savran MM, Konge L, Bjerrum F. Three-dimensional versus two-dimensional vision in laparoscopy: a systematic review. Surgical endoscopy. 2016 Jan 1;30(1):11-23

7. Rigante M, La Rocca G, Lauretti L, D'Alessandris GQ, Mangiola A, Anile C, Olivi A, Paludetti G. Preliminary experience with 4K ultra-high definition endoscope: analysis of pros and cons in skull base surgery. Acta Otorhinolaryngologicaitalica. 2017 Jun;37(3):237

8. Vettoretto N, Foglia E, Ferrario L, Arezzo A, Cirocchi R, Cocorullo G et al (2018) Why laparoscopists may opt for three-dimensional view: a summary of the full HTA report on 3D versus 2D laparoscopy by S.I.C.E. (SocietaItaliana di ChirurgiaEndoscopica e NuoveTecnologie). SurgEndosc 32(6):2986–2993

9. Sahu D, Mathew MJ, Reddy PK. 3D Laparoscopy-help or hype; initial experience of a tertiary health centre. Journal of clinical and diagnostic research: JCDR. 2014 Jul;8(7):NC01.

10. Bilgen K, Üstün M, Karakahya M, Isik S, Sengül S, Çetinkünar S, Küçükpinar TH. Comparison of 3D imaging and 2D imaging for performance time of laparoscopic cholecystectomy. Surgical Laparoscopy Endoscopy & Percutaneous Techniques. 2013 Apr 1;23(2):180-3.

11. Tung KL, Yang GP, Li MK. Comparative study of 2-D and bichanneled 3-D laparoscopic images: Is there a difference?. Asian journal of endoscopic surgery. 2015 Aug;8(3):275-80

12. Koppatz HE, Harju JI, Sirén JE, Mentula PJ, Scheinin TM, Sallinen VJ. Three-dimensional versus two-dimensional high-definition laparoscopy in transabdominal preperitoneal inguinal hernia repair: a prospective randomized controlled study. SurgEndosc. 2020 Nov;34(11):4857-4865. doi: 10.1007/s00464-019-07266-z. Epub 2019 Nov 21. PMID: 31754852; PMCID: PMC7572346.

13. Arezzo A, Vettoretto N, Francis NK, Bonino MA, Curtis NJ, Amparore D, Arolfo S, Barberio M, Boni L, Brodie R, Bouvy N. The use of 3D laparoscopic imaging systems in surgery: EAES consensus development conference 2018. Surgical endoscopy. 2019 Oct;33(10):3251-74

14. Thomaschewski M, Jürgens T, Keck T, Laubert T, Benecke C. Learning Laparoscopic Surgery Skills With a 4K Ultra-High Definition 2D vs a Three-Dimensional HD Laparoscopic System: Results From a Prospective Randomized Trial. Surgical Innovation. 2021 Feb 3:1553350621991224

15. Harada H, Kanaji S, Hasegawa H, Yamamoto M, Matsuda Y, Yamashita K, Matsuda T, Oshikiri T, Sumi Y, Nakamura T, Suzuki S. The effect on surgical skills of expert surgeons using 3D/HD and 2D/4K resolution monitors in laparoscopic phantom tasks. Surgical endoscopy. 2018 Oct;32(10):4228-34

16. Dunstan M, Smith R, Schwab K, Scala A, Gatenby P, Whyte M, Rockall T, Jourdan I. Is 3D faster and safer than 4K laparoscopic cholecystectomy? A randomised-controlled trial. Surgical endoscopy. 2019 Jul 18:1-7.

17. Esposito, C., Alberti, D., Settimi, A., Pecorelli, S., Boroni, G., Montanaro, B. and Escolino, M., 2021. Indocyanine green **(**ICG**)** fluorescent cholangiography during laparoscopic cholecystectomy using RUBINA™ technology: preliminary experience in two pediatric surgery centers. Surgical Endoscopy, 35**(**11**)**, pp.6366-6373.