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RESEARCH ARTICLE

A REVIEW OF THE HISTORY OF ROBOTICS AND EXPERIENCE OF TOTAL ROBOTIC HYSTERECTOMY ON VERSIUS ROBOTIC SYSTEM IN A TERTIARY CARE HOSPITAL IN NORTH INDIA

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ABSTRACT

Introduction and background: Robotic revolution has influenced all aspects of human life, the field of medicine is one of them. Robotic technology is the latest in surgical armamentarium that looks very promising. Versius is the next-generation robotic system, developed by a British private limited company CMR surgical, which has been useful in conducting over 1000 surgeries globally by November 2020 since its introduction in the year 2018. The aim of the present review article is to give an objective evaluation of robotic technology and to share our experience on total robotic hysterectomy with or without salpingo-oophorectomy using Versius robotic system. **Methods:** A review of the literature on robotics was undertaken using google search. Various studies describing the history and development of robots in the field of surgery were included in the present study. Epidemiological, clinical, laboratory, and radiological characteristics and intraoperative and follow-up data were obtained with data collection forms from electronic medical records and history given by six patients planned for hysterectomy with Versius robot admitted in PSRI Hospital, Delhi. All the patients had completed their family and they underwent Hysterectomy with or without bilateral salpingo-oophorectomy by Versius robotic system. **Results:** During the course of this study for seven patients who underwent total robotic hysterectomy with or without bilateral salpingo-oophorectomy average duration was 207 minutes and the indication for the surgery in five patients was abnormal uterine bleeding and in two patients it was postmenopausal bleeding. The average intraoperative blood loss was 120 ml. six out of seven patients were discharged the next day after the procedure. **Conclusion:** The evolution of robotic armamentarium in the surgical field is no doubt a milestone. We figured out that, robotic surgery can be highly advantageous with the learning curve and appropriate training and skill, along with proper patient selection. Versius robotic system is a revolution in the healthcare system, not only it is doctor friendly also it is patient-friendly too. For minimally invasive gynecologic surgery, Robot-assisted surgery provides an alternative surgical tool.

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INTRODUCTION

Robotic revolution has influenced all the aspects of human life, the field of medicine is one of them. Robotic technology is the latest in surgical armamentarium that looks very promising. For gynaecologic procedures, robotic surgeries were approved in the year 2005 by U.S. FDA since then it has evolved exponentially (Advincula, 2009; Aarts, 2015). Decreased wound infections, bleeding, and duration of hospital stay and rapid-return of patients to routine are the primary advantages of this minimally invasive approach Compared to abdominal procedures (Visco, 2008).

The aim of the present review article is to give an objective evaluation of robotic technology and to share our experience on total robotic hysterectomy with or without salpingo-oophorectomy using Versius robotic system. The development and evolution of robotic surgery will be discussed in this article also we will discuss review of current robotic systems, data available on robotics and also its role in surgeries in future.

Aims and Objectives

- To review the history of robotics
- To share the experience of first seven total robotic hysterectomy on CMR versius robot

History and background: In 1921, Czech playwright Karel Capek gave the term robot in his play *Rossum's Universal Robots*, since then robots have gained popularity both in imagination and reality (Satava, 2002; Felger, 2002). Term robot is derived from the Czech *robota*, meaning forced labor. In modern world robots are used to do highly particular, detailed, meticulous and risky jobs in the field of research and industries which was previously impossible with human beings. Robots are designed to explore the deep sea, work in untoward climatic situations and also to manufacture microprocessors used in computers. However entry of robot in health care facilities has been comparatively late. In 1985, Kwok *et al* used the very first robot Puma 560, performed neurosurgical biopsies with great precision. After Three years, Puma 560 was used by Davies *et al.*, they did a transurethral resection of the prostate (Davies, 2000). This system was the basis for development of PROBOT, a robot which was specifically designed for transurethral resection of the prostate. Simultaneously Integrated Surgical Supplies Ltd. of Sacramento, CA, was developing a robotic system designed to machine the femur with greater precision in hip replacement surgeries named ROBODOC (Satava, 2002). ROBODOC was the first surgical robot approved by the FDA.

The capabilities of both da Vinci and Zeus systems are similar but their approaches to robotic surgery are different. Both systems are comprehensive master-slave surgical robots with multiple arms operated remotely from a console with video assisted visualization and computer enhancement. The basis of da Vinci system was the telepresence machines developed for NASA and the US Army, it comprises of 3 components: a moveable cart, where 2 instrument arms and the camera arm are mounted and a vision cart that holds a dual light source and dual 3-chip cameras and a master console for the operating surgeon to sit. The camera arm consists of dual cameras and 3-dimensional image is generated. The master console comprises of a computer that generates a true 3-dimensional image with depth of field; the surgeon views the image via view port; foot pedals for electrocautery, camera focus, instrument/camera arm clutches, and master control grips that moves the servant robotic arms at the patient's side (Kim, 2002). The instruments provide 7 degrees of freedom and are cable driven. This system gives the surgeon the illusion that the tips of the instruments are an extension of the control grips by displaying its 3-dimensional image above the hands of the surgeon, thus giving the impression of being at the surgical site. The Zeus system has two components a surgeon control console and 3 table-mounted robotic arms. The arms of the surgeon are replicated by right and left robotic arms, and the third arm is for visualization, which is an AESOP voice-controlled robotic endoscope. In the Zeus system, the surgeon is seated comfortably upright with the video monitor and to maximize dexterity instrument handles positioned ergonomically and allow complete visualization of the OR environment. The system uses two types of instruments one is straight shafted endoscopic instrument similar to conventional endoscopic instruments and the other jointed instruments with articulating end-effectors and 7 degrees of freedom. Several robotic systems are currently approved by the FDA for specific surgical procedures. As mentioned previously, ROBODOC is used in hip replacement surgery to precisely core out the femur. Computer Motion Inc. of Goleta, CA, has 2 systems on the market. One, called AESOP, is a voice-controlled endoscope with 7 degrees of freedom.

This system can be used in any laparoscopic procedure to enhance the surgeon's ability to control a stable image. The Zeus system and the Da Vinci system have been used by a variety of disciplines for laparoscopic surgeries, including cholecystectomies, mitral valve repairs, radical prostatectomies, reversal of tubal ligations, in addition to many gastrointestinal surgeries, nephrectomies, and kidney transplants. The number and types of surgeries being performed with robots is increasing rapidly as more institutions acquire these systems. Perhaps the most notable use of these systems, however, is in totally endoscopic coronary artery grafting, a procedure formerly outside the limitations of laparoscopic technology. The Versius system has a small form factor, versatility and portability, and is designed to support surgeons to deliver the benefits of minimal access surgery to patients around the world. The form factor and modular design includes individually cart-mounted arms, allowing it to move between operating rooms and even hospitals/clinics, giving the surgical team access to patients at all times. By bio-mimicking the human arm, Versius gives surgeons the freedom of port placement, but with the benefits of small fully-wristed instruments. The system also includes 3D HD vision, easy-to-adopt instrument control and a choice of ergonomic working positions, aimed to reduce stress and fatigue to help extend the careers of surgeons.

MATERIALS AND METHODS

A review of the literature on robotics was undertaken using google search. Various studies describing the history and development of robot in the field of surgery were included in the present study. Epidemiological, clinical, laboratory, and radiological characteristics and intraoperative and follow up data were obtained with data collection forms from electronic medical records and history given by six patients planned for hysterectomy with Versius robot admitted in PSRI Hospital, Delhi. All the patients had completed their family and they underwent Hysterectomy with or without bilateral salpingo-oophorectomy by Versius robotic system. Versius is the next generation robotic system, developed by a British private limited company CMR surgical, popular across Europe and Asia and has been useful in conducting over 1000 surgeries globally by November, 2020 since its introduction in the year 2018. This robotic system allows surgeons to choose optimised port placement and numbers of arms needed to do the particular procedure. Its 3D HD vision, instrument control which is easy to adopt. In this study we have described the clinical profiles of the patients who underwent total Robotic hysterectomy by CMR Versius robot, ranging from their age, clinical symptoms, past surgical history, Clinical diagnosis, histopathology reports, laboratory evaluation, ultrasound and other radiological characteristics, operating time, Intraoperative findings and difficulties, blood loss during surgery along with duration of hospital stay and the condition at follow up. The described cases are the one planned for total hysterectomy with or without bilateral salpingo-oophorectomy via robotic route at a tertiary care hospital in North India.

RESULTS AND DISCUSSION

During the course of this study for eight such patients who were planned for total robotic hysterectomy with or without bilateral salpingo-oophorectomy the consent for the procedure was obtained on the day of surgery and bowel preparation was

done a night prior with charcoal and Dulcolax tablets and also they were given Tablet alprax 0.25 mg. Seven out of eight patients underwent robotic hysterectomy as one patient had endometriosis and adenomyosis with chronic pelvic pain, we had planned robotic hysterectomy for her. Our robotic set up was kept ready on the day of the procedure but we had to perform conventional laparoscopic hysterectomy for her as she had frozen pelvis and grade 4 endometriosis which was observed after trocar insertion and due to non-availability of harmonic scalpel, vessel sealer and ligasure in robotics we had to do it conventionally via laparoscopy. Our first case was Para 2, Live 2, Abortion 2, preoperative diagnosis of Abnormal uterine bleeding was made and hysteroscopic biopsy revealed Atypical hyperplasia was taken up for Total robotic hysterectomy with b/l salpingoophorectomy. On per speculum examination Cervix and vagina healthy on per vaginal examination Uterus 14 week size, IntraOp significant findings were bilateral tubes normal, Left ovary – normal, right ovarian cyst 6cm X 7 cm. Post-Operative histopathology report showed proliferative endometrium, leiomyoma in the myometrium, chronic cervicitis, corpus luteum cyst in the right ovary and simple cyst in the left ovary.

Our second case was Para 2 Live 2, both the deliveries were Normal vaginal deliveries and was diagnosed with abnormal uterine bleeding (AUB E/P) and endometriotic cyst. She had a past history of ectopic for which laparotomy was done 20 years ago. On per speculum examination her cervix was hypertrophied, bleeding per vaginum present polyp present, on per vaginum examination her uterus was 10 week size retroverted. Intraoperative findings were uterus 10 week size, multiple uterine fibroids, left ovarian endometrioma removed, right ovary was stuck to ovarian fossa which was separated and removed. Post-operative period was uneventful. Post-Operative histopathology report showed proliferative endometrium, adenomyosis and leiomyoma in the myometrium, chronic cervicitis with corpus luteum cyst in the left ovary. Our third patient, who was 58 years age, para 2 live 2 with previous both caesarean section with midline skin incision come with complaints of postmenopausal bleeding and she had undergone umbilical Hernia repair in the past. Her endometrial biopsy revealed endometrioid carcinoma grade 3. Preoperative PET scan was also done which showed no metastasis. Intraoperative adhesions were encountered which were released and operating time was 3 and half hours and the blood loss was around 100 ml. She was transfused 2 units of blood post operatively. She was discharged on the next day. Postoperatively on follow up histopathology revealed endometrioid carcinoma with squamous differentiation, grade 2. Fourth patient was a 44 year female, P2L2A1 Came with AUB E/P, pre op endometrial biopsy revealed Proliferative endometrium, underwent Total robotic hysterectomy with b/l salpingectomy with Left ovarian cystectomy via Versius robotic system. On P/S Cervix hypertrophied, Vagina Normal on P/V examination Uterus -8 to 10 week size, mobile and b/l fornix free Significant operative findings were Left ovarian follicular cyst removed. Our fifth patient was 62 years age, P2L2 came with Postmenopausal bleeding on hysteroscopy biopsy Atypical Endometrial hyperplasia was reported. She underwent Total robotic hysterectomy with b/l salpingoophorectomy. On P/S Cervix and vagina – healthy, on P/V examination Uterus – 10 week size, b/l fornix free, anteverted and mobile Intra op findings were uterus 10 week size, Bleeding from left vault secured with difficulty. Duration of procedure was 210 minutes and total blood loss was 100ml.

duration of hospital stay was one day only. Post Op histopathology finding was atypical endometrial hyperplasia with focal early endometrioid carcinoma FIGO, Grade I. post op period was uneventful. Our sixth patient was 49 years age, P2L2A1 came with complaints of heavy menstrual bleeding on hysteroscopy biopsy Proliferative endometrium and benign endometrial polyp was reported. She underwent Total robotic hysterectomy with b/l salpingoophorectomy. On P/S Cervix hypertrophied, cervical erosion present on anterior lip, bleeding present, on P/V examination Uterus- 14 to 16 week size, anteverted, bilateral fornix free Intra op findings were - bowel adhered to uterus on the left side – released, uterus 16 week size with multiple fibroids, bilateral tubes and ovaries - normal. Duration of procedure was 265 minutes and total blood loss was 100ml. duration of hospital stay was one day only. Post Op histopathology finding was Proliferative endometrium, adenomyosis and leiomyoma in the myometrium, acute on chronic cervicitis with simple cyst in the right ovary. Post op period was uneventful.

Our seventh patient was 43 years age, Para 1, Live 1, Abortion 1, came with complaints of heavy menstrual bleeding on hysteroscopy biopsy Proliferative endometrium was reported. She underwent Total robotic hysterectomy with b/l salpingectomy. On P/S Cervix hypertrophied, circumoral erosion present, bleeding present, on P/V examination Uterus- 20 week size, mobile, multiple fibroids felt. Intra op findings were – bowel and omentum adhered to right anterior abdominal wall– released, right ovarian simple cyst was drained and haemostasis achieved. 20 week size uterus with multiple fibroids removed and sent for histopathology. Duration of procedure was 212 minutes and total blood loss was 250ml. duration of hospital stay was one day only. Post Op histopathology finding was Proliferative endometrium, leiomyoma in the myometrium, chronic cervicitis with simple cyst in the left ovary. Post op period was uneventful. Average duration of these seven hysterectomies performed on Versius robot was 207 minutes with minimum and maximum duration being 152 and 265 minutes respectively. Average intraoperative blood loss was 120 ml. Six out of seven patients who underwent robotic surgery were discharged the next day of operation and one patient requested for one extra day of hospital stay due to personal reasons.

Our experience during these seven hysterectomies was quite satisfactory. It was feasible, less strenuous and provided easy manipulation of instruments as well as tissues with increased degree of freedom and smoothness. Surgeon friendly as surgeon can sit comfortably at the open console with the 3D spectacles on which allows them to sit in their comfortable position and reduces physical fatigue from surgery. The portability and ergonomic nature of Versius system was a great help as it was less space consuming. Additionally, it is patient friendly as shorter hospital stay, reduced pain and patient can gain mobility sooner. There is a rapid increase in the amount of data being generated on robotic surgery. There have been various studies that evaluate the feasibility of robot-assisted surgery. Cadiere *et al* in their study conducted on 146 patients to evaluate the feasibility of robotic laparoscopic surgery in those cases. ⁸<https://www.ncbi.nlm.nih.gov/labs/pmc/articles/PMC356187/> #r20-3 Procedures performed with a Da Vinci robot included 2 hysterectomies, 48 cholecystectomies, 28 tubal reanastomoses, 39 antireflux procedures, 10 gastroplasties for obesity, 3 intrarectal procedures, 3 inguinal hernia

repairs, 2 arteriovenous fistulas, 2 prostatectomies, 2 cardiac procedures, 1 endometriosis cure, 1 appendectomy, 1 lumbar sympathectomy, 1 varicocele ligation, 1 laryngeal exploration and 1 neosalpingostomy. This study established the feasibility of robotic laparoscopic surgery. They also stated that for manipulations in very small intra-abdominal spaces the robot was very useful. There was no robot related morbidity in those cases. Falcone *et al* in their study evaluated the feasibility of robotics in microsurgical tubal reanastomosis (Hollands, 2002). In their study, 10 patients who had past history of tubal sterilization procedure underwent tubal reanastomosis. 6 weeks postoperatively they found that the 19 tubes were reanastomosed successfully and 17 of the 19 were still patent and resulted in 5 pregnancies in this group so far. Margossian and Falcone conducted their study using Zeus robotic system on 10 pigs who underwent adnexal surgery or hysterectomy to assess the feasibility of robotic surgery in complex gynecologic surgeries (Margossian, 2001). They stated that robotic surgery is feasible and safe for such surgeries. Marescaux *et al*, in a prospective study on 25 patients undergoing telerobotic laparoscopic cholecystectomy tested for the safety and feasibility (Tozzi, 2002). Twenty-four of the 25 procedures were performed successfully, and one had to be converted to a traditional laparoscopic procedure. This study concluded that robotic laparoscopic cholecystectomy is safe and feasible.

Another study by showed telerobotic laparoscopic radical prostatectomy to be safe and feasible with remarkably increased dexterity¹². For noncancerous gynecologic disease various randomized controlled trials (RCTs) were conducted to compare robotic surgery with laparoscopy and none of the study showed robot-assisted approach to be superior (Deimling, 2017; Soto, 2017; Wijk, 2018; Sarlos, 2012; Paraiso, 2011; Paraiso, 2013; Anger, 2014; Lonnerfors, 2015). There is limited data that compare robotic laparoscopic surgery to vaginal surgery. So far four RCTs have compared robotic hysterectomy with laparoscopic hysterectomy (Deimling, 2017; Sarlos, 2012; Paraiso, 2013; Lonnerfors, 2015). Out of which studies conducted by Sarlos D *et al*, Paraiso MF *et al*. and Lonnerfors C *et al*. showed no differences in perioperative outcomes, including duration of hospital stay, blood loss, complications, postoperative pain levels, analgesic consumption, or recovery period (Sarlos, 2012; Paraiso, 2013; Lonnerfors, 2015). Data on operative duration were varied. Sarlos D *et al*. and Paraiso MF *et al*. in their study found robot-assisted hysterectomy took significantly longer operative times than laparoscopy with mean difference of 29 minutes and 77 minutes respectively (Sarlos, 2012; Paraiso, 2013). Conversely, Deimling TA *et al*. and Lonnerfors C *et al*. in their study reported similar operative durations when comparing robotic hysterectomy with laparoscopic hysterectomy (Deimling *et al.*, 2017; Lonnerfors, 2015). Incidence of vaginal cuff dehiscence after any hysterectomy is reported to be 0.14–4.1% overall. For robotic hysterectomy the incidence of vaginal cuff dehiscence is reported to be 0.4–2.61% (Kashani, 2012; Dauterive, 2012; Uccella, 2015). Study done by Dauterive *et al.* (2012) showed no difference in vaginal cuff dehiscence rate when compared robotic hysterectomy with laparoscopic hysterectomy.

CONCLUSION

Evolution of robotic armamentarium in surgical field is no doubt a mile stone. We figured out that, robotic surgery can be highly advantageous with the learning curve and appropriate training and skill, along with proper patient selection. Versus robotic system is a revolution in healthcare system, not only it is doctor friendly also it is patient friendly too. For minimally invasive gynecologic surgery, Robot-assisted surgery provides an alternative surgical tool. Although it has been shown to be feasible, more randomised control studies are needed to assess its efficacy and patient safety. Further studies are needed to assess cost effectiveness or benefits of robotics over conventional and laparoscopic hysterectomy procedures.

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