Literature Review

Laparoscopic Robotic Surgery in Gynecology

Operasi Laparoskopi Robotik pada Ginekologi

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Abstract

Objective: To know the development and application of robot assisted laparoscopy in gynecology.

Method: Literature review.

Result: Laparoscopy procedure has been widely used since the last three decades where minimally invasive surgery cases and demands increase in urology, cardiac surgery, general surgery, and particularly, gynecology. To date, laparoscopy has developed into robot-assisted laparoscopy due to needs of precise dissection of delicate structures, procedures which requires sophisticated technique, and surgeon's fatigue through the laparoscopy procedure. There are three robotic system which are commercialized and had been approved by FDA: AESOP, ZEUS, and Da Vinci, the latest robotic system which is used worldwide nowadays. There are advantages of robotic systems and conventional laparoscopy to open surgery laparotomy, such as diminished morbidity rate; less esthetical incisions; decreased post and intra operative blood loss, postoperative pain, use of pain medication, less cosmetic problems, and shorter length of hospital stay. Advantages of robotic surgery compared to conventional laparoscopy and laparotomy; include improved dexterity, more precise and accurate articulation, reduced tremor and surgeon's fatigue, and better visualization of the operating field because of 3D image. Robotic system has drawbacks such as limited area of surgery field in trocar-placing to avoid collision of the robotic arms, longer operative time, and a higher cost.

Conclusion: The major drawback of robot-assisted laparoscopy is in the term of cost; because of the high cost of robotic system; which could be overcome by a lower morbidity rate, less incisional aesthetic problem, less total intra operative blood loss, decreased demand of analgesics post operative, and shorter length of hospitalization stay and recovery time; as compensation of the high cost of robotic system. Further researches to study about the learning curve of robotic laparoscopy to achieve a faster operative time are needed. A longer operative time in robotic system can be anticipated with accurate simulation training in robotic system. There is also a need for further researches to discuss the total peri-operative cost.

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Keywords: laparoscopy, robotic system, robot-assisted, Da Vinci system, learning curve, gynecology

Abstrak

***Tujuan**: Untuk mengetahui perkembangan dan aplikasi laparoskopi berbantu-robot pada bidang ginekologi.*

***Metode**: Kajian pustaka.*

***Hasil**: Laparoskopi telah digunakan secara luas sejak tiga dekade terakhir di mana kasus dan permintaan akan pembedahan invasif minimal meningkat pada bidang urologi, bedah jantung, bedah umum, dan khususnya ginekologi. Hingga saat ini, laparoskopi telah berkembang menjadi laparoskopi berbantu-robot seiring meningkatnya kebutuhan akan diseksi yang akurat pada struktur yang lembut, kebutuhan akan teknik laparoskopi yang kompleks, dan kebutuhan untuk mengurangi kelelahan sepanjang laparoskopi. Ada tiga sistem robotik yang telah dikomersialisasikan dan disetujui oleh FDA: AESOP, ZEUS, dan Da Vinci, sistem robotik yang terbaru yang telah digunakan di seluruh dunia saat ini. Beberapa keuntungan sistem robotik dan laparoskopi konvensional dibandingkan dengan laparotomi, seperti rendahnya angka morbiditas, berkurangnya insisi yang berpengaruh pada estetika, menurunnya jumlah kehilangan darah saat dan pascaoperasi, berkurangnya angka kesakitan dan penggunaan anti nyeri pascaoperasi, perawatan pascaoperasi yang lebih cepat. Keuntungan sistem robotik apabila dibandingkan dengan laparoskopi konvensional adalah peningkatan ketangkasan serta ketepatan artikulasi, berkurangnya risiko tremor dan kelelahan operator, dan visualisasi lapangan operasi yang lebih jelas karena visualisasi 3D. Namun demikian, sistem robotik memiliki kekurangan seperti daerah penempatan trokar yang terbatas untuk mencegah benturan antar lengan robotik, waktu operasi yang lebih lama, dan biaya sistem robotik yang mahal.*

***Kesimpulan**: Kelemahan utama dari laparoskopi berbantu-robot adalah biaya yang mahal. Namun hal ini dapat dikompensasi dengan rendahnya angka morbiditas, rendahnya angka masalah estetika, rendahnya jumlah kehilangan darah perioperatif, berkurangnya kebutuhan akan anti nyeri perioperatif, dan lama perawatan dan pemulihan yang lebih cepat. Waktu operasi yang lebih lama dapat diantisipasi dengan latihan simulasi sistem robotik yang akurat. Selain itu, dibutuhkan juga penelitian yang membahas tentang kurva pembelajaran laparoskopi robotik untuk mencapai waktu operasi yang lebih cepat dan penelitian yang membahas tentang biaya total perioperatif.*

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***Kata kunci**: laparoskopi, robotik, sistem Da Vinci, kurva pembelajaran, ginekologi*

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INTRODUCTION

Laparoscopy procedure has been widely used since the last 3 decades. To date, laparoscopy has spawned new technologies; such as camera-technology and laparoscopies replacing the invasive laparotomy. There are several procedures that could be done by laparoscopy, especially in gynecology. Robot-assisted surgery is one of the newest innovations in minimally invasive surgery. Urology, gynecology, cardiac surgery, and general surgery have applied the robot-assisted surgery. In 2004, 10% of radical prostatectomy in United States are done by robot-assisted laparoscopy.[1] There are some procedures in gynecology that were reported to be assisted by robotics in 1999, Falcone reported that tubal reanastomosis procedures had already been successfully assisted by robotic system.

In 2002, Diaz-Arrastia reported the first 11 patients done by robotic-computerized laparoscopy histerectomy.[1] Advincula reported 31 patients that had robot

assisted laparoscopy myomectomy which is robotic-assisted. There are some references about robotic laparoscopy for sacral colpopexy and tuba ligation.[1]

The use of robot-assisted surgery has developed rapidly in recent years as patients' request for robot-assisted surgery increases due to actions of minimally invasive procedures compared with the general open surgery. Precise dissection of delicate structures, such as a firmly adherent ureter due to lateral pelvic wall endometriosis, is difficult to do with conventional laparoscopy and requires sophisticated technique. An advanced laparoscopy procedure requires some suturings of technical skills are not easily mastered with conventional laparoscopy. Precise dissection of delicate structures, such as a firmly adherent ureter due to lateral pelvic wall endometriosis, is difficult with conventional laparoscopy and requires sophisticated technique. Therefore, the time of procedure is longer, leading to decreased surgical precision from surgeon's fatigue.[2] Robotic technology has been introduced in order to overcome this problem. Da Vinci Surgical System is one of the FDA-approved robotic systems currently on the market.[3] More than 645 units Da Vinci System are widely used over the world and approximately 41 units have been installed in Asia, especially in South Korea where it was approved by Korean FDA and firstly used in 2005. Da Vinci system-assisted hysterectomy procedure was first used in Korea in January 31st 2006.[4] There is one unit of Da Vinci System which has been installed in Bunda Hospital, one of private hospital in Jakarta, since January 2012.

Conventional laparoscopy and robot-assisted laparoscopy diminish morbidity rate, lessen esthetical incisions, decrease post and intra operative blood loss, post operative pain, use of pain medication, reduce cosmetic problems, and decrease length of hospital stay.[2,3] Advantages of robotic surgery compared to conventional laparoscopy and laparotomy are improved dexterity, more precise and accurate articulation, reduced tremor, and better visualization of the operating field. Control mechanism of robotic system as base on the direction of operator's hands, in the contrary of mirror-movement as in the conventional laparoscopy. In spite of advantages conventional laparoscopy has compared to robotic-assisted laparascopy; conventional laparoscopy has some limitations such as 2D visualization with an unsatisfied depth of perception, disturbance of the eye-hand-target axis, the fulcrum effect, limited degrees of movement, and less tactile feedback.[5,6]

Robotic Surgical System

Generally, there are three main components of robotic surgical system: surgical cart, vision cart, and surgeon's console.[7]

There are three commercialized robotic systems that take part in gynecological history. The first robotic system is AESOP (Automated Endoscopic System for Optimal Positioning) in 1993, which functioned as a laparoscope holder.[2,7] AESOP is the first FDA-approved robotic system and used in abdomen endoscopy for optimal position. Recent days, AESOP has developed into voice-controlled in position-controlling.[2,7]

The second Robotic system, ZEUS, is the first robotic system that assisted gynecological procedures in 1999.[2] ZEUS is actually a modified AESOP with an addition of two robotic arms to hold surgical ins-truments. The ZEUS system has three remotely controlled robotic arms, allowing a single surgeon to manipulate the laparoscope camera and two laparoscopic surgical instruments simultaneously.[2,7] The arms that hold the surgical instruments are controlled by two handles housed in a mobile console that can be positioned anywhere in the operating room or in a different location.[2]

The third robotic system is the Da Vinci System. Da Vinci system, produced by Intuitive Surgical (Sunnyvale, CA, USA), has been available since 1998 and approved for general surgery by the US Food and Drug Administration (FDA) in 2000, for the use in urology in 2001 and gynecology in 2005.[6]

Several advantages with Da Vinci System have been identified, such as: 3-dimensional visualization of the operative field with depth perception, additional degrees of freedom and downscaling of instrument movements, restoration of the eye-hand-target axis and enhanced stability, elimination of the fulcrum effect, and improved ergonomics position for the surgeon.[7] This advantages show development from the

Figure 1. Da Vinci System: surgeon's console and docking system. (photo: WH)

previous system, ZEUS. Some researches have been done in comparing between ZEUS and Da Vinci, and all results, Da Vinci showed shorter operation time.[7]

The basic concept of this application is similar with the concept of robotic system in general, which consists of three main components: surgeon console, surgical cart, and vision cart. The surgeon sits at a console separated from the surgical field and movement of handles at the console results in the movement of surgical instruments at the operative field. Surgeon looks into the console which has a dual-lens system and a 3D 10-fold magnification.[2,6] (Figure 1)

There are some limitations in this system, such as loss of tactile and force feedback, which can be overcome by training and is partially compensated for by the 3D visual feedback. Limited area of surgery field in trocar-placing to avoid collision of the robotic arms and increased operation time are other limitations of this system.[3] However, the major limitation of this technology is the high cost per unit, high annual maintenance, and disposable robotic surgical instrument.

Cost of Robotic-Assisted Surgery

Laparoscopy is generally said to have a shorter length of stay, lower post operative scar and pain, lower risk of infection, and lower rate of peri operative blood loss; hence the post operative cost is lower than open surgery.[2,3,8] Robotic technology has been used widely in the last four years in the United States and Europe. The number of robot-assisted procedures which are performed worldwide has nearly tripled from 80000 to 205000 procedures.[8] Particularly, Da Vinci System which is used in the United States has increased approximately 75% from 800 units to 1400 units in 2007 - 2009.[8]

There is a major difference in operative cost between open surgery laparotomy, laparoscopy, and robotic-assisted surgery resulting from added expense of specialized equipment. Equipment cost associated with laparoscopic surgery has a relatively low per-case number as its multifunction such as monitors and cameras can be used also for hysteroscopy. The cost of Da Vinci robot is € 1.5 million (US$ 1 million - US$ 2.5 million) per unit.[3,8] Da Vinci system needs a maintenance cost of € 150,000 annually and cost for disposable robotic instrument.[3,8] Average operation time of robotic system is longer than conventional laparotomy.[8] Higher cost of disposable surgical instrument is the main cause of high cost in robotic system. As a comparison, disposable instrument in conventional laparoscopy is $1,138, while to cost for disposable surgical instrument for robotic laparoscopy is $ 2,210.[9]

In 2010, Magnus Anderberg compared a learning curve between conventional laparoscopy and robotic laparoscopy. 20 subjects of 500 medical students from Lund University were chosen randomly to do some procedures by using a conventional laparoscopy and robotic laparoscopy. The result was that robotic laparoscopy had a faster procedure time compared to conventional laparoscopy. However, there was a steeper curve of procedure time in conventional laparoscopy which means that the operator was more likely to adapt faster using conventional laparoscopy.[5] There are some efforts to suppress cost and reduce operation time. For instance, several institutions have a computer-based simulations for operators to train and adapt to robotic surgical instrument, suppresing the cost of learning curve. Hospitalization time is also a factor of the total cost. The shorter the hospitalization time, the cheaper the total cost can be; this is due to cost for post operative procedures which includes blood loss cost, post operative analgesic cost, and length of stay.[2,3] Hospitalization cost of laparoscopy and robotic system is less than open surgery laparotomy which has some complications. Although, there are several researches that reported that hospitalization cost of laparoscopy and robotic system is not significantly different.[3] Therefore, cost problem of robotic system can be overcome by suppressed hospitalization cost.[8]

Robotic-Assisted Surgery in Gynecology

Robotic-assisted surgery has developed since the last four years and widely used in minimally invasive surgery, particularly in Gynecology. Laparoscopy-assisted hysterectomy was first used in 1992 based on Childers and Surwit, although there was survey by the Society of Gynecologic Oncologists (SGO) that only 49% of gynecologists in the United States used the laparoscope to stage endometrial cancer, and less than 8% of them performed laparoscopic surgery.[10] Reasons for not adopting laparoscopic surgery which are often cited by surgeons are: prolonged operating times which results in surgeon's fatigue, a difficult and prolonged learning curve, and lack of formal training in advanced laparoscopic technique. Therefore, robotic-assisted laparoscopic hysterectomy has quickly replaced conventional laparoscopic in a relatively short time since 2005. Approximately 60% of endometrial cases are completed robotically and length of stay has reduced from 3.2 days of laparotomy to 1.0 day.[10]

Longer operative time and learning curve are among the reasons why robot-assisted laparoscopy has not yet been adopted worldwide and needs to be researched and innovated further. Total operative time consists of docking time and console time. Docking time is the time needed to assemble instruments and attach patient to the robot, fastening the robotic arms to the inserted trocars, and introducing the laparoscope. Console time is defined as the surgical time needed to perform the entire operation at the console.[11]

Hysterectomy

Hysterectomy is the hallmark of surgical gynecology. Minimally invasive procedures have been applicated in hysterectomy procedure since the 1990.[10,12] There are complex pathologies; such as endometriosis, uterine leiomyoma, and chronic tubo-ovarian complexes with adhesions; which have presented challenges for the laparoscopic surgeon. Hence, robotic laparoscopy is applicated in hysterectomy in order to overcome this challenge.

In 2009, Holloway compared five publications which compared open surgery laparotomy with la-

paroscopy, and robotic-assisted laparoscopy in hysterectomy procedure of endometrium cancer. The result of this publication is an average operation time is of 79 - 147 minutes in laparatomy, 177 - 283 minutes in robotic-assisted laparoscopy, and 171 - 287 minutes in conventional laparoscopy.[10] Advincula performed hysterectomy in 6 patients with cases of advanced pathology, such as pelvic adhesions of which the scarred or obliterated anterior cul-de sac. Advincula suggested to do robotic-assisted laparoscopy in this advanced pathology because of the demand for minimally invasive surgery meanwhile there are some limitations of surgery field, surgeon's skill, and technical skill in conventional laparoscopy.[13] Renato compared total blood loss between hysterectomy laparotomy, conventional laparoscopy, and robotic-assisted laparoscopy in two publication and he found that hysterectomy laparotomy had the greatest intra operative blood loss, while robotic-assisted laparoscopy had the lowest intra operative blood loss.[11]

In 2010, Sarlos compared hysterectomy peri-operative data of patients with robot-assisted laparoscopy and conventional laparoscopy. Sarlos also collected questionnaires filled by surgeons to get surgeons' subjective assessments about advantages of the robotic procedure. These data showed that the mean operative time of laparoscopic robotic surgery was longer (108.9 minutes) than the mean operative time of conventional laparoscopy (82.9 minutes); the total intra operative blood loss of robotic laparoscopy was greater (81 ml) than conventional laparoscopy (< 50 ml). There was no significant difference for length of stay between robotic laparoscopy and conventional laparoscopy (3.3 days vs 3.9 days).[12] There are relatively same results obtained by Pasic stating that the total operative cost in robotic laparoscopy is more expensive than conventional laparoscopy. In terms of operative time and length of stay, there is no significant difference between robotic laparoscopy and conventional laparoscopy.[14]

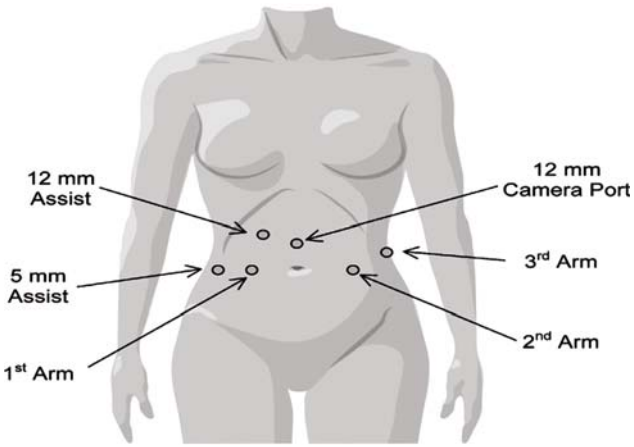

Figure 2. Trocar position in (robot) robotic-assisted laparoscopy hysterectomy.[10]

Insertion port of the camera is approximately 19 - 27 cm above the symphisis pubis, depending on patient's height, uterine size, and length of trunk; in order to keep the camera from being too close to the uterus or pelvic mass therefore enabling the operator to get an adequate visualization of the anatomy. 12-mm trocar is inserted in the right upper quadrant while 5-mm trocar is inserted in the right flank as the second robotic arm in the left flank. The third robotic arm is inserted 9 - 10 cm from the second arm, therefore the third robotic arm can extract and expose using double fenestrated grasper and can reach the pelvic with "S" instruments.[10] (Figure 2)

Reproductive Endocrinology

In 1998, Robotic system was firstly used in reproductive endocrinology. There are several studies which compared the result of tubal anastomosis via Da Vinci system and open micro surgery. Degueldre reported comparable operating times to that of open microsurgery, and pregnancy was reported in 2/8 patients at 4 months following the surgery. In 2004, a feasibility study in a fellowship training program was carried out at the University of Alabama, comparing open microsurgical technique versus the Da Vinci surgical system in tubal anastamosis of 18 patients looking for sterilization reversal and robotic laparoscopy resulted in greatly increased operative times, though length of hospital stay, recovery time, and time to return to independent activities of daily living were significantly shorter as compared to the open microsurgery.[10] (Figure 3)

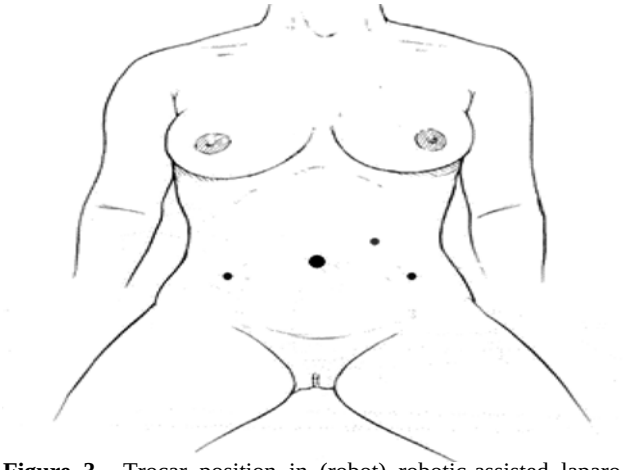

Figure 3. Trocar position in (robot) robotic-assisted laparoscopy tubal anastomosis.[10]

Myomectomy

Surgical treatment of infertility patients with uterine leiomyoma is controversial, because there is no defined causal relationship between uterine myoma and infertility. There is an opinion that uterine myoma alter fertility either by interfering with sperm migration and embryo transport, or by causing vascular changes that impede embryo implantation. The role of robot-assisted laparoscopy in myomectomy is to improve the quality of intraabdominal sutures. Some studies reported that myomectomy done with robotic-assisted laparoscopy had a longer operative time but a shorter recovery time than conventional laparoscopy.[10] (Figure 4)

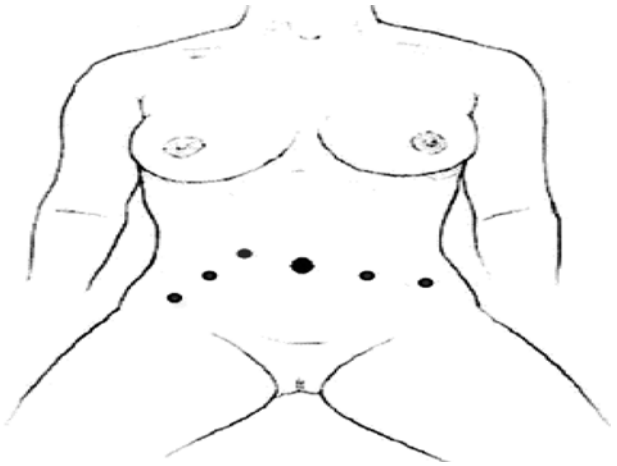

Figure 4. Trocar position in (robot) robotic-assisted laparoscopy myomectomy.[10]

Pelvic Reconstructive Surgery

Nowadays, sacrocolpopexy has used robotic system to assist the surgery. Some operators use robotic system to suture, meanwhile the others use robotic for the whole procedure. The major benefits of robotic-assisted surgery are clear visualization, dexterity, and precise dissection of pre-sacral spaces. In 2004, robotic system was firstly used in pelvic reconstructive surgery by DiMarco and mean operative time of 31 patients was 3.1 hours with a hospitalization time of 24 hours. Geller compared robotic laparoscopy and abdominal sacrocolpopexy. Mean operative time of robotic laparoscopy was longer than sacrocolpopexy; meanwhile total blood loss was less and length of stay was shorter in robotic-assisted laparoscopy.[10]

CONCLUSIONS

In the last four years, robot-assisted surgery has developed rapidly, especially in gynecology. The major drawback of robot-assisted laparoscopy is in the term of cost because of the high cost of robotic system unit, disposable robotic surgical instruments, and the high cost of annual robotic maintenance. This disadvantage can be compensated by a lower morbidity rate, less incisional aesthetic problem, less total intra operative blood loss, decreased demand of analgesic post operation, and shorter length of hospitalization stay; further researches are srill needed to study about the learning curve of robotic laparoscopy to achieve a faster operative time. There is also a need for further researches to discuss the total peri-operative cost with a variety of variables such as total cost of operation, post operative medical costs, and hospitalization cost in order to be to comparison with the total peri-operative costs of laparoscopic robotic, conventional laparoscopy, and open surgery laparotomy. The authors hope that the year of 2012 will be the milestone for Indonesia to begin an era of robotic surgery.

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