Robotic Urologic Surgery-2011.

Narmada P. Gupta
Department of Urology, Medanta- The Medicity, Gurgaon, Delhi NCR, India

***Abstract**: Nephroureterectomy with excision of cuff of bladder is the standard treatment of upper tract transitional cell carcinoma. Role of endoscopic treatment, either percutaneous or ureteroscopic, has been established in imperative indications like solitary kidney, bilateral tumors and deranged renal functions. Elective indications of endoscopic treatment include tumor size <1.5cm, low grade tumors with normal contralateral kidney. The most important part which affects the success and prognosis following endoscopic treatment is careful selection of patients andregular ureteroscopic surveillance following surgery. Various studies have compared nephroureterectomy with endoscopic treatment in low grade tumors and concluded that both cancer related and overall survival is same in both the approaches. Adjuvant therapy with mitomycin, thiotepa and BCG has been described. However no study has shown statistical improvement regarding survival and recurrence rates following adjuvant therapy. Patients with low grade, small sized tumors have equal outcomes with endoscopic treatment as compared to expirative surgery with the advantages of minimal morbidity and preservation of renal parenchyma following endoscopic management. For the standardization of endoscopic treatment for patients with normal contralateral kidney, large randomized trials with long follow up results are needed.*

INTRODUCTION

Urologists are pioneer in endoscopy and started endoscopic surgery more than 100 years back. This was followed by endourologic, Laparoscopic and now Robotic Urologic Surgery. During the last 10 years, significant progress had been made in robot assisted laparoscopic surgery and a new standard of care has been set up for many Urologic diseases[1,2].

The term *robot* was first coined by Karel capek in 1921 in his play *Rossums Universal Robots.* The robot word was derived from the Czech word "*Robota*" meaning *"Industrial worker".* It has gained popularity through science fiction such as *Blade Runner & Star Wars.* The robots are in use in every walk of our life and now are being introduced in the operation theatre.

A robot can be defined broadly as a mechanical device that is controlled using a computer system. The first medical specialities to use robots were neurosurgery and orthopaedics. Robotic systems were developed for neuronavigation, stereotactic localization, and robotic assistance. *Neuro Mate* is commercially available FDA approved device. In Orthopaedics, the *Robodoc* was developed for placement of prosthetic joints. Robots became popular in cardiac surgery for coronary bypass surgery. In general surgery, it is used in Bariatic surgery, in gynaecology, for reversal of tubal ligation, vault prolapsed, hysterectomy etc.

The first Urologic surgery with the assistance of robot was transurethral resection of prostate performed by Wickham in 1979, however due to uncontrolled resection and bleeding, this has not become popular. In Italy, robot was used to perform TRUS guided biopsy but did not provide any advantage. At John Hopkins Medical center, Percutaneous access to the Kidney (PAKY) was developed with the assistance of robot and the system is currently being evaluated clinically. Automated Endoscopic System for Optimal Positioning (AESOP) was the first active robotic device approved by the FDA. AESOP is a robotic arm with motorized joints that is controlled by a surgeon through the speech recognition system. Endo-Assist is a similar device, but the arm is controlled by the surgeon's head movement. These devices have paved the way for Master Slave devices (da Vinci Surgical system), which at present is manufactured only by Intitutive Surgicals, USA. A group of urologist in 1996 in France started robotic radical prostatectomy but it was popularized by Mani Menon from Detroit, USA in 2001. Today, there are more than 1400 da Vinci robots installed all over the world and mainly used in Urologic surgery. After seeing the success in Urology, all other surgical specialities have started exploring its utility.

da VINCI SURGICAL SYSTEM

The da Vinci surgical system consists of a surgeon's computer console for surgeon interaction, a surgical cart that houses the video and lighting equipment, and a robotic tower that supports three or four arms. The surgeon's console provides the user a three-dimensional view through a binocular viewport. Interaction is through "masters" in to which surgeon inserts his or her hands. The masters allow free movement that is translated intuitively in to seven degrees of freedom at the robotic instruments tips. A double lens laparoscopic system is combined in to a single three dimensional binocular view. The robotic tower supports three or four robotic with one arm controlling the camera. Endowrist instruments come in a wide range including graspers, scissors, hook, knives, hot scissors and surgical energy devices.

The master slave system has advantages of an ergonomic environment for performing surgery for the surgeon. Surgeon can make natural hand movements rather than counter intuitive movements. It filters hand tremors and scale movements, by digitizing surgeon's hand movements. The robotic arms provide additional degree of freedom inside the patient's body. It provides 3-D view of the surgical field & improves depth perception. With the seven degree of freedom at the instrument tips and 3-D view, suturing becomes much simpler in comparison to laparoscopic surgery.

The port placement is important in robotic surgery to avoid robotic arm collisions. The robotic arms are heavy and there should be a minimum gap of 8 cms between the ports. The camera port and other robotic ports should be in triangulation for easy suturing. There is lack of tactile sensation in robotic surgery which is compensated by magnification and visuals[3].

The **Patient's advantage of robotic surgery** is that it is a minimally invasive procedure with less morbidity, shorter hospital stay and early return to work.

The **disadvantage of robotic surgery** is the initial cost of equipment and cost of reusable robotic instruments. At present, the usage is

***Correspondence: Prof. Narmada P. Gupta**, Chairman, Academic and Research, Department of Urology, Medanta- The Medicity Gurgaon, Delhi NCR, India **e-mail:**narmadagupta@gmail.com*

limited to only 10 per instrument. As a result, cost of the surgery is more compared to open and conventional laparoscopy. As any new procedure, there is a learning curve in the robotic surgery also, however in comparison to laparoscopic surgery; there is a shorter learning curve for the complex urological procedures. The duration of surgery is same as for open surgery and initially may longer during the learning period. The comparative trials are going on to find out the efficacy and effectiveness of robotic surgery in comparison to open and laparoscopic surgery. At present, there are no training facilities in India where as dry and wet animal lab facilities for training in robotic surgery are desirable.

Fig. 1: *da Vinci S4 Robotic System at Medanta*

ROBOTIC RADICAL PROSTATECTOMY

Robot-assisted radical prostatectomy (RARP) is a rapidly evolving technique for the treatment of localized prostate cancer. In the United States and Europe, this technology is accepted well. RARP seems to have overtaken retropubic radical prostatectomy (RRP) as the treatment of choice due to patient preference for minimally invasive surgical options. In USA, over 80% of Radical Prostatectomies are Robot-assisted, but the acceptance of this technology in Asian countries is slower due to several reasons. Chiefly being, high cost of the Robotic system and instruments, higher maintenance cost and poor affordability by the patients, as most of the patients are paying on their own due to lack of insurance. Apart from this, the number of the cases of localized prostate cancer are less due to lower incidence in Asian population, the lack of community based screening programs and presentation of cases in advanced stage.

Dr. Mani menon, in 2001, started, refined and popularized robot assisted radical prostatectomy. He described transperitoneal approach, bladder neck first procedure and named it as VIP technique. To improve the functional outcome of RALP, there has been several modifications of VIP like various grades of nerve sparing technique, ligation of DVC at the end and posterior and anterior reconstruction of the bladder neck etc[4,5,6].

Following RALP, there is reduction in the morbidity of the procedure, shorter hospital stay, less medical complications, significantly less or no blood transfusions and early return to work. The functional outcome by way of biochemical recurrence, urinary incontinence and erectile dysfunction is same as in open surgery, but as the experience is growing and new modifications are being introduced, chances are that they will also get better[7,8,9].

Amongst the Asian countries, largest number of Robotic system are installed in Korea, followed by India, Singapore, Hongkong, Malaysia and recently in Japan. Most of the installations were funded by Government agencies and cost of the procedure is subsidized. The numbers of cases done in these centers are limited and there are only a few published papers on RARP from Asia. Few Asian centers have reported their initial experience and are now crossing over the period of learning curve. The results are optimum, however the long term follow up is awaited[10].

Fig. 2: *Robot after docking*

ROBOTIC BLADDER SURGERY

Robot-assisted radical cystectomy (RARC) offers an attractive minimally invasive alternative to the current gold standard of open radical cystectomy (ORC) for muscle-invasive bladder cancer and high-risk non-muscle-invasive disease[11]. The interest generated since the initial description of RARC[12,13]. has been immense and larger case series are now appearing in the literature. Pruthi *et al*. reported their initial experience with 100 patients who underwent RARC and found that there were no positive surgical margins and that the mean hospital stay was 4.9 days, with mean bowel movement being at 2.8 days. The complication rate appeared to be 36%, with 8% of these being Clavien grade III or higher[14]. In a mean follow-up of 21 months, the authors reported that 15 patients manifest recurrent malignancy with 6 individuals succumbing to their disease[14]. The same group reported the first prospective randomised trial of ORC versus RARC in 41 patients and found that there was no significant difference in postoperative complication rate (33% RARC vs. 50% ORC; $P = 0.279$) and mean hospital stay (5.1 days RARC vs. 6.0 days ORC; $P = 0.239$) [15]. The investigators reported that RARC had a longer operative time than ORC (4.2 vs. 3.5 hr; $P < 0.001$), but that there was less intraoperative EBL associated with RARC (258 vs. 575 ml; $P < 0.001$) [15]. RARC also appeared to confer quicker time-to-bowel movement and time to flatus with less use of narcotic analgesics for pain relief. This landmark study used a prospective randomized clinical trial to demonstrate that RARC was not inferior in comparison to ORC and matched up favorably with respect to various intraoperative and postoperative outcomes[15]. Initially, extracorporeally urinary diversion was done following Laparoscopic and Robotic assisted cystectomy. Intracorporeal urinary diversion is a complex procedure and needs experience and long operating time. With increased experience and expertise, some centers started intracorporeal diversion. While there is still much work that needs to be done to assess long-term oncological outcomes, RARC is an

evolving technique that affords patients and physicians alike an efficacious minimally invasive treatment option in the treatment of bladder cancer.

Robot-assisted partial cystectomy (RAPC) can also be performed in a select group of patient with localized tumour at the dome or for Urachal tumours. Few cases have been reported in the literature[16,17].

Fig. 3: Surgeon sitting at Robotic Console

ROBOTIC KIDNEY SURGERY

After successful use of Robot for Prostate surgery , its use extended to kidney surgery. Common robotic surgery are Radical Nephrectomy, Partial Nephrectomy, Pyeloplasty, Nephroureterectomy, for cystic lesions and stone disease, chyluria etc.

Robot-assisted partial nephrectomy (RAPN) was first described in 2004 by Gettman *et al*.[18] It has since enjoyed widespread adoption at many high-volume centres. Recent evidence suggests that RAPN offers equivalent oncological control to open partial nephrectomy (OPN) and laparoscopic partial nephrectomy (LPN) while providing the additional benefit of shorter hospital stay, less intraoperative EBL and shorter warm ischaemia time (WIT)[19]. In an analysis of over 100 RAPN and LPN cases, no significant difference was found in the rate of focal positive margins between the two modalities[20]. While it may be too early to assess long-term oncological control in this relatively new surgical technique, early results from a series of 100 RAPN showed no tumour recurrence at 12 months[21]. Intraoperative EBL during partial nephrectomy has been shown to be an accurate predictor of early and late recovery of kidney function[22], and considering that 26% of patients undergoing partial or radical nephrectomy have some degree of renal impairment preoperatively[23], RAPN holds the promise of better long-term nephron preservation. Studies also show that RAPN generally provides shorter WIT as compared to LPN[24]. This seems to hold true even in cases that require calyceal repair, have complex renal tumours or have multiple tumours[25]. New evidence reveals that RAPN has a relatively short learning curve with regard to parameters such as acceptable WIT and total operative time. All the aforementioned advantages suggest that RAPN will garner widespread acceptance as the minimally invasive treatment of choice for small renal masses.

Robot-assisted pyeloplasty (RAP) provides a viable alternative to the current gold standard open approach for the treatment of ureteropelvic junction (UPJ) obstruction[26]. Gettman *et al*. reported one of the earlier comparisons of RAP with the laparoscopic approach and found that the robotic method was associated with less operating time[27]. Gupta and colleagues reported their initial experience with 86 patients and found that RAP was associated with a mean operative time of 121 minutes (mean anastomosis time of 47 minutes), mean EBL of 45 ml and mean hospital stay of 2.5 days. Most importantly, the success rate was found to be 97% at a mean follow-up of 13.6 months[28]. Recent reports have shown that RAP can be employed efficaciously in cases of complicated UPJ obstruction, which include horseshoe kidney, malrotated kidney, ectopic kidney and giant hydronephrosis, to name a few[29]. Gupta *et al*. also described a transmesocolic approach to RAP for left UPJ obstruction in 24 patients, which had a perfect success rate at a mean 1-year follow-up with no repeat obstructions[30].

Robot-assisted nephroureterectomy with excision of the bladder cuff is done for Upper tract transitional cell carcinoma (TCC). Early feasibility studies show that robot-assisted nephroureterectomy with excision of the bladder cuff (RANUT) provides a viable treatment option for this long and technically challenging procedure[31]. Eandi and colleagues reported their initial experience with 11 patients who underwent RANUT for upper tract TCC and showed promising short-term intraoperative and postoperative outcomes with regard to oncological efficacy, hospital stay, EBL and operative time[32]. This was the first case series to utilise a completely robotic approach but required undocking and redocking of the da Vinci system during the procedure to allow for better surgical access. As can be inferred, this increased total operative time by 10-15 minutes[33].

Percutaneous nephrolithotomy is the current treatment of choice for large renal stones but robot-assisted extended pyelolithotomy (REP) provides an appealing option in cases of staghorn calculi and in patients undergoing concurrent RAP[34-35]. Hemal and coworkers found that in six patients who underwent REP or robot assisted pyelolithotomy, the mean operative time was 106 minutes and EBL was less than 50 ml in all cases[36]. One patient required conversion to an open procedure because the renal calculus could not be localised. The study also assessed 29 cases of RAP with concomitant pyelolithotomy for UPJ obstruction with a secondary stone, and deemed the procedure to have a 97% symptomatic efficacy rate[37].

Fig. 4: Robotic Intra Operative view

ROBOTIC UROGYNAECOLOGIC PROCEDURES

The robotic repair of primary vesicovaginal fistula was first described in five patients by Sundaram *et al*. in 2006 and was associated with acceptable postoperative outcomes[38]. In a matched comparative analysis of open versus robotic repair of recurrent vesicovaginal fistula, robot-assisted techniques were found to be more effective in regard to better morbidity related outcomes while providing similar postoperative success rates[39]. Hemal and coworkers presented the first report of robotic repair of complex vesicouterine fistula.

ROBOTIC URETERIC SURGERY

Robotic assistance is increasingly being utilised in a variety of

urologic procedures and is furthering the applicability of this exciting technology. Hemal and colleagues recently reported the feasibility of robotic intracorporeal or extracorporeal ureteric tapering with ureteroneocystostomy for primary symptomatic obstructive megaureter, ureteroureterostomy for retrocaval ureter, ureteral stump excision and ureterosciatic hernia repair[39,40].

CONCLUSION

Robotic surgery is a significant advance in the realm of urologic surgery esp. for urogenital cancers and for reconstructive procedures. It is associated with ease in dissection, incision and suturing with less steep learning curve in comparison to laparoscopy. It provides all benefits of minimally invasive surgery.

The development of Robotic surgery is slower in Asian countries due to high cost of the robotic system and instruments. Robotic surgery is practiced in few hospitals in Asia. The overall cost of robotic surgery is less in Asian countries in comparison to USA and Europe with similar outcomes. For widespread use of robotic surgery, cost of the robotic system and instruments has to come down to make it affordable for a large Asian population. We hope the cost of the robotics and their instruments will come down to make it affordable for a large population.

REFERENCES

1. **Hemal AK, Menon M.** *Laparoscopy, robot, telesurgery and urology: future perspective. J Postgrad Med. 2002;48:39–41.*
2. **Hemal AK, Menon M.** *Robotics in urology. Curr Opin Urol. 2004;14:89–93.*
3. **Hemal AK, Eun D, Tewari A, Menon M.** *Nuances in the optimum placement of ports in pelvic and upper urinary tract surgery using the da Vinci robot. Urol Clin North Am. 2004;31:683–92.*
4. **Menon M.** *Robot-assisted radical prostatectomy: Is the dust settling? Eur Urol. 2011;59:7–9.7. Coelho RF, Rocco B, Patel MB, Orvieto MA, Chauhan S, Ficarra V, et al. Retropubic, laparoscopic, and robot-assisted radical prostatectomy: A critical review of outcomes reported by high-volume centers. J Endourol. 2010;24:2003–15.*
5. **Menon M, Hemal AK.** *Vattikuti Institute prostatectomy: a technique of robotic radical prostatectomy: experience in more than 1000 cases. J Endourol. 2004;18:611–9.*
6. **Tewari AK, Bigelow K, Rao S, Takenaka A, El-Tabi N, et al.** *Anatomic restoration technique of continence mechanism and preservation of puboprostatic collar: a novel modification to achieve early urinary continence in men undergoing robotic prostatectomy. Urology 2007; 69: 726–31.*
7. **Menon M, Hemal AK.** *Vattikuti Institute prostatectomy: a technique of robotic radical prostatectomy: experience in more than 1000 cases. J Endourol. 2004;18:611–9.*
8. **Menon M, Bhandari M, Gupta N, Lane Z, Peabody JO, Rogers CG, et al.** *Biochemical recurrence following robot-assisted radical prostatectomy: Analysis of 1384 patients with a median 5-year follow-up. Eur Urol. 2010;58:838–46.*
9. **Patel VR, Coelho RF, Chauhan S, Orvieto MA, Palmer KJ, Rocco B, et al.** *Continence, potency and oncological outcomes after robotic-assisted radical prostatectomy: early trifecta results of a high-volume surgeon. BJU Int. 2010;106:696–702.*
10. **Yip SKh, Sim HG.** *Robotic Radical Prostatectomy in east asia: development, surgical results and challenges. Curr opin. Urol. 2010 Jan; 20(1): 80-5. Review. PMID: 19887945.*
11. **Richards KA, Hemal AK, Kader AK, Pettus JA.** *Robot assisted laparoscopic pelvic lymphadenectomy at the time of radical cystectomy rivals that of open surgery: Single institution report. Urology. 2010;76:1400–4.*
12. **Hemal AK, Abol-Enein H, Tewari A, Shrivastava A, Shoma AM, Ghoneim MA, et al.** *Robotic radical cystectomy and urinary diversion in the management of bladder cancer. Urol Clin North Am. 2004;31:719–29.*
13. **Menon M, Hemal AK, Tewari A, Shrivastava A, Shoma AM, Abol-Ein H, et al.** *Robot-assisted radical cystectomy and urinary diversion in female patients: technique with preservation of the uterus and vagina. J Am Coll Surg. 2004;198:386–93.*
14. **Menon M, Hemal AK, Tewari A, Shrivastava A, Shoma AM, El-Tabey NA, et al.** *Nerve-sparing robot-assisted radical cystoprostatectomy and urinary diversion. BJU Int. 2003;92:232–6.*
15. **Pruthi RS, Nielsen ME, Nix J, Smith A, Schultz H, Wallen EM.** *Robotic radical cystectomy for bladder cancer: surgical and pathological outcomes in 100 consecutive cases. J Urol. 2010;183:510–4.*
16. **Nix J, Smith A, Kurpad R, Nielsen ME, Wallen EM, Pruthi RS.** *Prospective randomized controlled trial of robotic versus open radical cystectomy for bladder cancer: perioperative and pathologic results. Eur Urol. 2010;57:196–201.*
17. **Allaparthi S, Ramanathan R, Balaji KC.** *Robotic partial cystectomy for bladder cancer: a single-institutional pilot study. J Endourol. 2010;24:223–7.*
18. **Stanasel I, Richard J, Hemal AK.** *Robotic assisted laparoscopic partical cystectomy. Abstract 1562 presented at World Congress of Endourology and SWL.*
19. **Gettman MT, Blute ML, Chow GK, Neururer R, Bartsch G, Peschel R.** *Robotic-assisted laparoscopic partial nephrectomy: technique and initial clinical experience with DaVinci robotic system. Urology. 2004;64:914–8.*
20. **Benway BM, Bhayani SB, Rogers CG, Dulabon LM, Patel MN, Lipkin M, et al.** *Robot assisted partial nephrectomy versus laparoscopic partial nephrectomy for renal tumors: a multi-institutional analysis of perioperative outcomes. J Urol. 2009;182:866–72.*
21. **Wang AJ, Bhayani SB.** *Robotic partial nephrectomy versus laparoscopic partial nephrectomy for renal cell carcinoma: single-surgeon analysis of >100 consecutive procedures. Urology. 2009;73:306–10.*
22. **Scoll BJ, Uzzo RG, Chen DY, Boorjian SA, Kutikov A, Manley BJ, et al.** *Robot-assisted partial nephrectomy: a large single-institutional experience. Urology. 2010;75:1328–34.*
23. **Colli J, Martin B, Purcell M, Kim YI, Busby EJ.** *Surgical factors affecting return of renal function after partial nephrectomy. Int Urol Nephrol. [Epub ahead of print]*
24. **Huang WC, Levey AS, Serio AM, Snyder M, Vickers AJ, Raj GV, et al.** *Chronic kidney disease after nephrectomy in patients with renal cortical tumours: a retrospective cohort study. Lancet Oncol. 2006;7:735–40.*
25. **Viprakasit DP, Altamar HO, Miller NL, Herrell SD.** *Selective renal parenchymal clamping in robotic partial nephrectomy: initial experience. Urology. 2010;76:750–3.*
26. **Gupta NP, Nayyar R, Hemal AK, Mukherjee S, Kumar R, Dogra PN.** *Outcome analysis of robotic pyeloplasty: a large single-centre experience. BJU Int. 2010;105:980–3.*
27. **Gettman MT, Peschel R, Neururer R, Bartsch G.** *A comparison of laparoscopic pyeloplasty performed with the daVinci robotic system versus standard laparoscopic techniques: initial clinical results. Eur Urol. 2002;42:453–7.*
28. **Hemal AK, Mukherjee S, Singh K.** *Laparoscopic pyeloplasty versus robotic pyeloplasty for ureteropelvic junction obstruction: a series of 60 cases performed by a single surgeon. Can J Urol. 2010;17:5012–6.*
29. **Nayyar R, Gupta NP, Hemal AK.** *Robotic management of complicated ureteropelvic junction obstruction. World J Urol. 2010;28:599–602.*
30. **Gupta NP, Mukherjee S, Nayyar R, Hemal AK, Kumar R.** *Transmesocolic robot-assisted pyeloplasty: single center experience. J Endourol. 2009;23:945–8.*
31. **Park SY, Jeong W, Ham WS, Kim WT, Rha KH.** *Initial experience of robotic nephroureterectomy: a hybrid-port technique. BJU Int. 2009;104:1718–21.*
32. **Eandi JA, Nelson RA, Wilson TG, Josephson DY.** *Oncologic outcomes for complete robot-assisted laparoscopic management of upper-tract transitional cell carcinoma. J Endourol. 2010;24:969–75.*
33. **Hemal AK, Stanasel I, Patel MN.** *Robotic assisted nephroureterectomy and bladder cuff excision without intraoperative repositioning. Urology. 2011 [In press]*
34. **Badalato GM, Hemal AK, Menon M, Badani KK.** *Current role of robot-assisted pyelolithotomy for the management of large renal calculi: a contemporary analysis. J Endourol. 2009;23:1719–22.*
35. **Badani KK, Hemal AK, Fumo M, Kaul S, Shrivastava A, Rajendram AK, et al.** *Robotic extended pyelolithotomy for treatment of renal calculi: a feasibility study. World J Urol. 2006;24:198–201.*
36. **Hemal AK, Nayyar R, Gupta NP, Dorairajan LN.** *Experience with robotic assisted laparoscopic surgery in upper tract urolithiasis. Can J Urol. 2010;17:5299–305.*
37. **Sundaram BM, Kalidasan G, Hemal AK.** *Robotic repair of vesicovaginal fistula: case series of five patients. Urology. 2006;67:970–3.*
38. **Gupta NP, Mishra S, Hemal AK, Mishra A, Seth A, Dogra PN.** *Comparative analysis of outcome between open and robotic surgical repair of recurrent supra-trigonal vesico-vaginal fistula. J Endourol. 2010;24:1779–82.*
39. **Hemal AK, Sharma N, Mukherjee S.** *Robotic repair of complex vesicouterine fistula with and without hysterectomy. Urol Int. 2009;82:411–5.*
40. **Laungani R, Patil N, Krane LS, Hemal AK, Raja S, Bhandari M, et al.** *Robotic-assisted ureterovaginal fistula repair: report of efficacy and feasiblity. J Laparoendosc Adv Surg Tech A. 2008;18:731–4.*