EDITOR'S PICK

The surgical robot has the advantage of enabling the console surgeon to perform complex procedures more easily, providing three-dimensional and magnified views, higher grades of wristed hand movements, and decreased hand tremor, while the fourth robotic arm offers additional assistance and tissue retraction which facilitates the learning curve. Robotic radical prostatectomy can be learned and performed successfully in the hands of surgeons without previous laparoscopic radical prostatectomy experience!

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RECENT DEVELOPMENTS IN MINIMALLY INVASIVE RADICAL PROSTATECTOMY

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ABSTRACT

Minimally invasive surgery has gained a dominant status in prostate cancer surgery during the last decade. The benefits of minimally invasive prostatectomy were demonstrated by pioneers of conventional laparoscopic prostatectomy, however, the real domination of laparoscopy in radical prostatectomy (RP) started after the dissemination of robotic surgery. Robot-assisted surgery still remains the most widespread method to perform minimally invasive RP, although the recent evolution of laparoscopic technology and instruments has evoked interest in conventional laparoscopy again. The recent developments in the technique of RP are focused on decreasing invasiveness and complications. The recent methods to improve postoperative functional outcome of RP can be utilised without compromising the oncological results.

Keywords: Prostate cancer, minimally invasive surgery, surgical technique, outcome.

INTRODUCTION

Intracapsular adenocarcinoma of the prostate is most effectively cured by total surgical elimination of the prostate. Even though the first reports of perineal prostatectomy date from 1901 by Proust and radical prostatectomy (RP) from the 1940s by Millin, surgical removal of the prostate remained an unpopular treatment modality for localised prostate cancer (PrC) due to its high perioperative and postoperative morbidity. Anatomical studies of the Santorini plexus[1] and cavernous nerves[2] by Walsh formed the scientific basis for the development of contemporary RP with acceptable treatment related morbidity and quality of life (QoL) combined with excellent oncological outcome. Since its introduction in the early 1980s, radical retropubic prostatectomy (RRP) with later modifications[3] has remained the gold standard for the surgical treatment of PrC.

EVOLUTION OF MINIMALLY INVASIVE RP

Minimally invasive surgery (MIS) was initially utilised in urology in the treatment of disorders of the upper urinary tract. Since the first laparoscopic nephrectomy,[4] the benefits of MIS in urological

indications soon became obvious; low perioperative morbidity combined with equal functional and oncologic outcomes made MIS a potential technique that could replace conventional surgery in several urological indications. RP, however, is a demanding procedure that requires great skill and dexterity when performed conventionally let alone by means of MIS. The first laparoscopic radical prostatectomies (LRPs) were reported by Schlusser et al.[5] and Guillonneau et al.[6] After initial enthusiasm, several early adopters discontinued performing LRPs due to the long operating time and slow learning curve. In expert hands LRP remained a viable technique[7] and its benefits in terms of low morbidity combined with good oncologic outcome were demonstrated.[8] However, global dissemination of endoscopic prostatectomy was long hindered by the long learning curve and lack of instrumentation that would ease the reconstructive phase of the procedure.

Robotic telesurgery was initially developed for the needs of military forces. In the beginning, commercially available robotic devices were utilised in thoracic surgery, but it was soon discovered that the 3D vision and superior dexterity enabled by the EndoWrist® make RP a particularly well-suited indication for robot-assisted laparoscopic surgery. Robot-assisted laparoscopic radical prostatectomy (RALRP) was first performed by Binder and Kramer[9] and reported by Abbou and associates.[10] Since its introduction, robot-assisted surgery has been criticised for the high economic burden that it causes to the healthcare system. However, this drawback is much outweighed by its benefits: low morbidity of MIS, short learning curve, and a superior potential of technical refinements of the surgical procedure. RALRP was popularised after the pioneer work of early adopters, who described the surgical procedure in detail and reported superior results.[11] Nowadays RALRP is the most common method used to perform RP in the United States, as well as in many European countries. For example in Finland, where robotic surgery landed in late 2008, around 80% of RPs were RALRPs in 2014 (unpublished data). The proportion of RALRP increased rapidly even though high-quality evidence of its superiority is lacking.[12] RALRP is dominant in affluent countries but cost is prohibitive for its universal application at present. Reduction of the cost of robotics may, in future, allow universal dissemination of minimally invasive RP. Compared to RRP, laparoscopic or robot-assisted radical prostatectomies have been shown to decrease blood loss and hospitalisation time.[8] It also seems that the complication rate after MIS is decreased.[8,13] However, no superiority in terms of oncological outcome nor postoperative urinary continence and potency has been demonstrated.[8] This review focuses on the recent developments in this field.

RECENT ADVANCES OF MINIMALLY INVASIVE PROSTATECTOMY

Although there are reports of several surgical robots that are under development worldwide, more than a decade after its introduction, the da Vinci robot by Intuitive Surgical (Intuitive Surgical, Sunnyvale, CA, USA) still remains the only commercially available robotic device. The fourth generation da Vinci Surgical System, da Vinci Xi, was only introduced recently. Da Vinci Xi features new advanced EndoWrist® instruments, free placement of the camera at any of the robotic arms, and a wider operation field. The new patient cart architecture with overhead arms facilitates preoperative arrangement by allowing easier docking of the patient cart (Intuitive Surgical, Inc., Press release, 1st April, 2014). In theory, the new da Vinci Xi may help in decreasing the operation room time, but there are no clinical studies yet to confirm this.

In contrast to open and laparoscopic surgery, in robotic surgery there is no physical contact between the surgeon and the patient. Distance between the surgeon and the surgical site is a challenge for the teaching and learning of robotic surgery. The European robotic urologic society has started a pilot study for European robotic curriculum.[14] This includes theoretical sessions, skills training, real-case observation, bedside assistance, and mentored training at the console. In the study, RALRP is divided into modules, which are categorised to levels of difficulty. As expertise grows, the trainee will start learning more difficult modules. Finally, the trainee is able to perform the whole procedure independently.[14] In laparoscopy, new generation 3D technology by Olympus (ENDOEYE FLEX 3D), Karl Storz (3D TIPCAM), Braun (Einstein Vision), and Richard Wolf (Endocam Epic 3DHD) have made 3D vision available also in conventional laparoscopic surgery. 3D display enhances the depth perception, spatial location, and surgical performance, for instance, in helping the surgeon to tie a knot.[15] In RP, 3D vision has been shown to decrease operative time (particularly that of performing the urethrovesical anastomosis),

lowers the operative blood loss and may help in improving the early continence rate.[16] Even after the recent developments of the technique of conventional laparoscopic prostatectomy, it seems that its outcomes (operative time, blood loss, hospital stay, potency recovery, and marginal status in organ-confined disease) remain slightly inferior to RALRP.[17]

The principle of minimising invasiveness has led to development of laparo-endoscopic single-site surgery (LESS). LESS has been shown to be feasible in several urological indications,[18] and it may be superior in terms of cosmetic results. Surgery via a single entry point is, however, technically challenging. Crossing instruments at the abdominal wall, lack of triangulation and instrument collision are the main difficulties of LESS surgery. Curved and angulated instruments and endoscopes have been developed to ease or overcome these challenges. Triangulation can be achieved by adding a needlescopic instrument in the configuration (hybrid LESS). Robotic manipulator decreases the trouble caused by crossing instruments at the abdominal wall and facilitates suturing. Furthermore, curved instrument cannulae and semi-rigid robotic LESS instrument have been developed. Even though robotic LESS RP is feasible and safe,[18] more developments and studies are needed before its universal clinical implementation is reasonable.

ONCOLOGICAL ASPECTS

RP is first and foremost an oncologic operation. Therefore, good oncological results must remain the main goal. Because the prognosis of localised PrC is good, great attention has to be paid also to satisfactory functional outcomes: nerve sparing is recommended if it is deemed oncologically safe. Preoperative evaluation including clinical examination, prostate specific antigen (PSA) determination, Gleason score, and the number of biopsy cores positive for cancer are used in this evaluation. Recently, preoperative magnetic resonance imaging (MRI) has also been utilised in the preoperative staging. Despite best efforts, unnecessary nerve sacrificing and incorrect nerve sparing still remain a common issue. Intraoperative neurovascular structure-adjacent frozen section examination (NeuroSAFE) of the prostate has been developed to minimise this problem.[19] The NeuroSAFE method has been shown to increase the nerve sparing rates from 81% to 97%, while decreasing positive surgical margin rates from 24% to 16%.[20]

Pelvic lymph node dissection is the most effective method to detect metastatic lymph nodes (MLNs) in PrC. Its significance to prognosis, however, is still controversial. While lymphadenectomy is safe during RALRP, it does increase the operative time and is associated with postoperative incidence of lymphoceles.[21] Despite the shown effectiveness of extended pelvic lymphadenectomy in nodal staging, isolated MLNs can also be found outside the common lymphadenectomy template.[22] The need to avoid unnecessary lymph node removal and to increase the sensitivity and specificity of the procedure, have been the main goals in the development of sentinel node (SN) mapping. Indocyanine green has been injected directly into the prostate and used as a tracer to detect lymphatic drainage.[23] Percutaneous robot guided injection of the tracer was shown to be the fastest, cheapest, and also the most aseptic method. Sentinel lymphatic drainage could be identified in the majority of patients by using this tracer. Fluorescence positivity was visualised subsequently by using Firefly® technology during robotic surgery. The method was shown to be highly sensitive but relatively nonspecific for the detection of nodal metastasis.[23] Indocyanine green technology was improved by van der Poel and co-workers[24] by using indocyanine green combined with technetium-99m tracer. Sentinel lymph nodes were detected by single-photon emission computed tomography computer tomography preoperatively and by fluorescence imaging intraoperatively.[24] Fluorescence-based SN visualisation was further optimised by increasing particle concentration, decreasing injection volume and by upgrading laparoscopic fluorescence imaging system (Image 1 HUB HD with D-Light P system). These improved the sensitivity of SN identification up to 93.5%.[25]

METHODS TO IMPROVE CONTINENCE

Incontinence is the most QoL decreasing side-effect of RP. Recent systematic review and meta-analysis has shown the incontinence rate after RALRP to be 0-11% at 1 year postoperatively.[26] Several methods have been developed to decrease and shorten the duration of postoperative incontinence. Rocco et al.[27] introduced posterior rhabdosphincter reconstruction (Rocco stitch) in RRP and showed improved postoperative continence rates. This technique was rapidly adapted to RALRP as well.

Modified Rocco stitch posterior reconstruction has been shown to decrease the urinary incontinence at 1 and 3 months after RALRP, but it has little effect on long-term continence rates.[28,29] However, in other studies, posterior rhabdosphincter reconstruction had no effect on urinary continence rates.[30-33] The putative effect of Rocco stitch was later analysed in a systematic review and meta-analysis. The cumulative analysis showed that posterior reconstruction caused small but significant improvement of urinary continence within 1 week (RR=1.79, p=0.03) and at 30-45 days (RR=1.57, p=0.004), but had no effect at 90 days postoperatively.[34] In summary, posterior rhabdosphincter reconstruction may improve short-term continence, but has no effect on long-term continence rates. Similarly Patel's method[35] to perform anterior periurethral suspension stitch has been shown to improve urinary continence at 3 months after RALRP without an effect on continence at 1, 6, and 12 months postoperatively. Our opinion is that the most important effect of posterior reconstruction is its positive effect on haemostasis, and that it permits construction of a tension-free urethrovesical anastomosis.

The concepts of either anterior or posterior reconstruction were further refined and a total pelvic floor reconstruction (posterior and anterior) technique was introduced. The total pelvic floor reconstruction showed significantly improved continence rates compared to posterior reconstruction only. The mean interval to achieve continence was also significantly shorter in the total pelvic floor reconstruction group (mean 7.7 months) than in the non-total pelvic floor reconstruction group (mean 9.8 months).[36] Later, other methods to perform periurethral reconstruction during RP have been reported. For instance Complete Reconstruction of the Posterior Urethral Support[37] is a recent method showing excellent immediate after catheter removal and 30 day postoperative continence results. Most likely these reconstructive methods have a positive effect on postoperative continence and they may shorten the time to reach continence, but their superiority is not yet thoroughly studied.

Bladder neck preservation leads to at least partial internal sphincter sparing. It is shown to improve urinary continence at 4 months from 26.5% to 65.6%,[38] leading to earlier recovery of urinary continence.[39,40] Furthermore, bladder neck preservation did not compromise cancer control, i.e. positive surgical margins[38] nor PSA recurrence during 5-year follow-up.[39] Similarly, maximal urethral length preservation improves postoperative continence rates and shortens time to achieve continence among patients undergoing RALRP without increasing the risk of positive margins.[41] The effect of urethral length and volume and proximity of levator muscle to membranous urethra on postoperative continence rates were studied by preoperative MRI-based measurements among 967 men. Urethral length and volume and close relationship between the levator muscle and membranous urethra were associated with recovery of urinary continence at 6 and 12 months after open RP.[42] The patients who had longer membranous urethral length measured by intra operative transrectal ultrasound had better continence rates at 1, 3, and 6 months after LRP.[43] It has been suggested that urethral length preservation may actually have more effect on continence than posterior rhabdosphincter reconstruction and anterior bladder suspension.[41]

Nerve sparing is naturally associated with better postoperative erectile results, but it may also improve urinary continence.[44] Therefore, nerve sparing should not be excluded from men with impaired preoperative erectile function. Also lateral prostatic fascia (endopelvic fascia) preservation during RALRP may have a positive effect on return of continence. When the effect of lateral prostatic fascia preservation during RALRP was studied in 151 men, the return of continence was significantly improved at 6 and 12 months postoperatively.[45] Similarly the preservation of puboprostatic ligaments improves continence rates at 2 weeks and at 3 months following surgery.[46] The complete method to spare a pubovesical complex maximises preservation of the pelvic supporting system. During this technically demanding procedure the prostate must be the shelled out underneath pubovesical complex, which may enhance immediate continence results.[47]

High quality of the anastomosis is an important factor to decrease catheterisation time and to prevent anastomotic strictures. Delayed healing of the anastomosis may also be associated with delayed urinary continence.[48,49] Prevention of urethrovesical anastomosis (UVA) leakages seems to be the most important factor to ensure undisturbed healing of the anastomosis. We performed a prospective randomised study in order to examine if a catheter with a side-fenestration at the site of the anastomosis could minimise leakages after RALRP. The extra fenestration of the

catheter prevents formation of pressure at the site of the anastomosis, which may occur if the ureteral orifices are located near the bladder neck under the catheter balloon. We showed that a side-fenestrated catheter decreases UVA leakage rates after RALRP from 12.3 % to 4.6 %.[50] Urinary catheter is a major factor causing discomfort after RALRP. Attempts have been made to avoid catheterisation altogether by using a suprapubic cystostomy as drainage. This method was shown to decrease pain after RALRP in about 50% and resulted in a 2.5-fold faster recovery of continence.[51,52] However, a randomised clinical trial could demonstrate no significant difference in postoperative pain among patients having either a suprapubic cystostomy or a urethral catheter.[53]

In its introduction, the most common method to reconstruct UVA during minimally invasive prostatectomy is the van Velthoven technique.[54] However, recently uni or bidirectional barbed sutures have increased in their popularity. Prospective randomised trials have shown that the use of barbed suture (V-Loc 180, Covidien, Mansfield, MA, USA) may shorten anastomotic time and improve the primary water tightness of the anastomosis.[55-57] On the other hand, when using barbed sutures, one has to pay attention to avoid over tightening, because it may lead to the postoperative anastomotic leakage.[55]

RECOVERY OF SEXUAL FUNCTION

Prediction of postoperative incontinence after RALRP is rather complex and an uncertain issue, whereas, erectile function is more straightforward to evaluate. Postoperative continence is important to all patients, but the need of postoperative sexual function varies; if the patient is sexually active, postoperative impotence may significantly worsen his QoL. The possibility to preserve sexual function after RP became obvious when Walsh et al.[2] introduced nerve sparing RRP in 1982. Initially it was described that neurovascular bundles are located in dorsolateral aspects of the prostate.[2] Later studies have demonstrated a whole network of periprostatic nerve fibres, some of which are also located on the anterior surface of the prostate. This finding has led to new improved methods of performing nerve sparing: e.g. 'The Veil of Aphrodite'.[11] Another important technique to improve erectile function postoperatively is to use a cautery-free technique.[58] Cavernous nerves are also sensitive to traction-induced neuropraxia. Studies have shown that countertraction on neurovascular bundle can delay recovery of sexual function and potency.[59,60]

Improved vision of surgical field during laparoscopy enable more precise visualisation and dissection of the prostatic fascia. Prostate can be released from surrounding tissue intra, inter, or extrafascially. Intra and interfascial planes enable nerve sparing but increase the risk of positive surgical margins. Extrafascial dissection improves cancer control but sacrifices erectile nerves. Therefore it is essential to make careful preoperative evaluation of the dissection plane in agreement with the patient.

CONCLUSION

RP is the treatment of choice for localised PrC. RRP has set the standard of anatomical dissection and resection. Laparoscopic and robotic surgeries have successfully adopted these principles without compromising cancer control and functional outcomes while delivering the advantages of MIS. Recently the main developments in PrC surgery are aimed to further decrease the incidence of complications related to RP, i.e. incontinence and impotence. Several surgical modifications have been developed as an attempt to reach this goal. However, it seems that the most significant factors to improve both oncologic and functional outcomes of prostate surgery are excellent anatomical knowledge and meticulous surgical technique.

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