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Title: Robotics in Australian Urology contemporary practice and future perspectives

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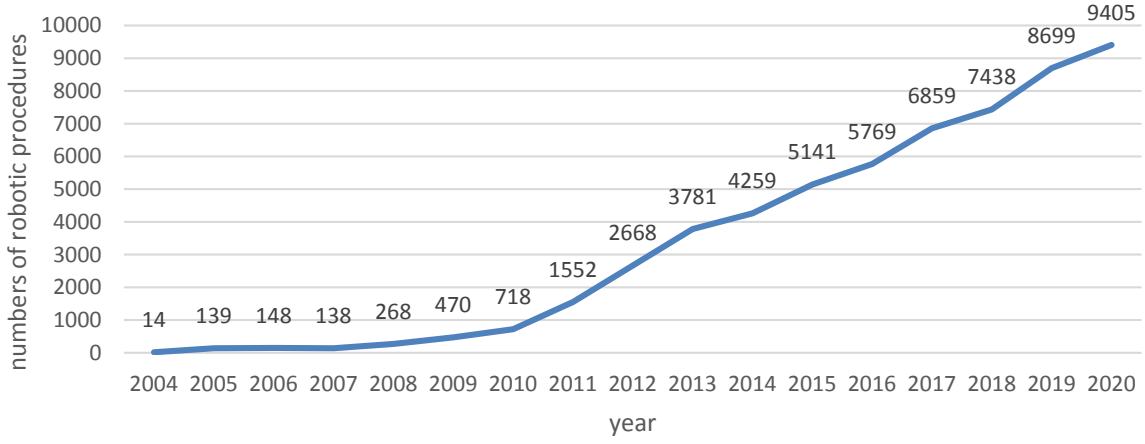
Robotic surgery began in Australia with the performance of a robot assisted radical prostatectomy at Epworth Hospital in Melbourne in 2003(1). Since then over 60,000 robotic procedures have been performed in Australia, steadily increasing to 9,405 robotic cases in 2020 (figure 1). Although robotic radical prostatectomy remains the commonest robotic procedure in Australia, having been performed over 50,000 times and accounting for 80% of all robotic cases last year, other disciplines have now embraced robotic surgery(2). In 2019, 65% of prostatectomies were performed robotically in Australia. Open and laparoscopic approaches accounted for 35% of cases (figure 2). By 2014, 90% of prostatectomies in the United States were performed robotically(3) and by 2019, 90% of prostatectomies in the United Kingdom were performed robotically(4). Robot-assisted prostatectomy is now standard of care in private practice in urology in Australia. This disparity between private and public provision occurs because there are few robots in the public sector, so public patients are offered an open or laparoscopic approach. Since 2010, the robotic approach has been used in multiple other urological surgeries. It is likely that within 5 years, all major urologic surgery will be done robotically in Australian hospitals. Robotic partial nephrectomy is now adopted as standard of care for small renal masses in hospitals with robotic technology. Other surgeries such as nephrectomy, nephroureterectomy, pyeloplasty, radical cystectomy with urinary diversion, and retroperitoneal lymph node dissection for testis cancer have become incorporated as robotic surgeries in high volume centres in Australia. In this manuscript we present review of current and emerging applications of urologic robotics in Australia. Robotic sacrocolpopexy will not be discussed in this section as this reconstructive procedure is more performed in gynaecology than urology.

Figure 1. Trend of robotic procedures in Australia beween 2004 - 2020



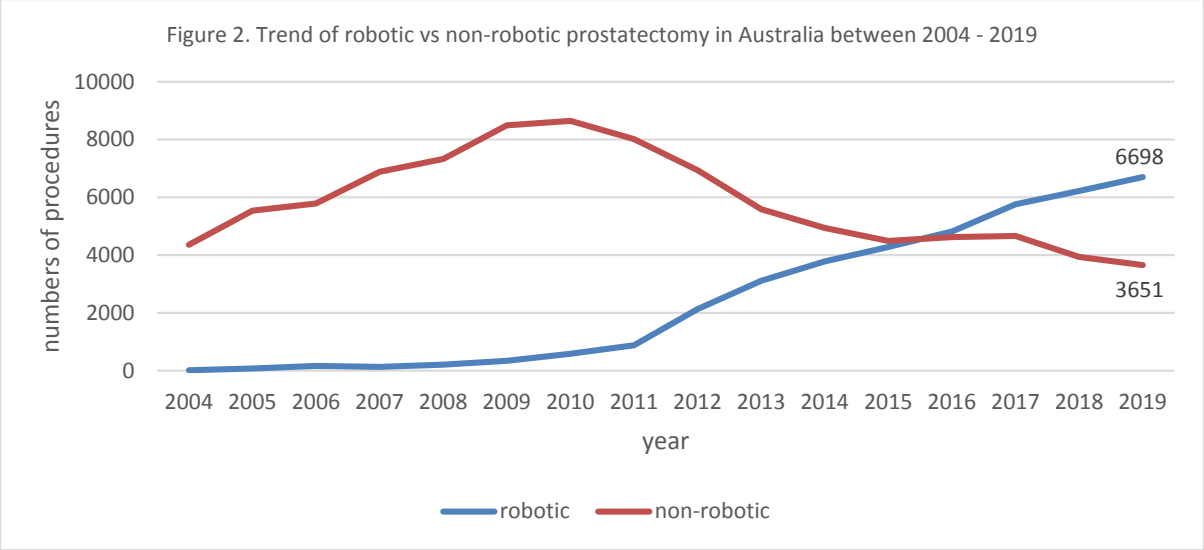
Source: Device Technologies Australia Pty Ltd(5)

Robotic radical prostatectomy

It was only after 1980, when Walsh first described how to perform safely open retropubic radical prostatectomy, that the operation became widely adopted. Before then, the operation was extremely hazardous for the patient because of major blood loss from the dorsal vein complex, as well as the lack of anatomical insights into the anatomical basis for neural potency anatomy and the continence mechanism of the urinary sphincter(6). Menon in 2002 used the robot to perform the difficult operation of retropubic radical prostatectomy, applying insights gained from open surgery to a minimally invasive

robotic approach(7). Radical prostatectomy by the open method is a technically difficult operation and has a steep learning curve. Similarly, robotic radical prostatectomy is a difficult operation for the novice and has a learning curve of between 50 and 300 cases to proficiency(8). The first Australian series of 400 robotic radical prostatectomy published in 2008 reported a complication rate from a single centre of 15.75% (9). The complication rate in a contemporary series has reduced to 6.6% and continence, potency, biochemical recurrence-free survival at 12 months and negative surgical margin rates have been reported at 96.4%, 89.8%, 96.4% and 90.7% respectively (10). Measurable quality of life outcomes following radical prostatectomy include urinary continence, potency recovery and cancer margin status. A landmark randomised controlled trial, comparing robotic radical prostatectomy versus open radical prostatectomy was performed by John Yaxley and colleagues in Brisbane. This study was reported in the Lancet in 2016(11). The study randomised patients to either open or robotic prostatectomy. The authors demonstrated very little difference in measurable outcomes between the methods. The difference lay in the advantages of minimally invasive surgery for the robotic approach which included reduced blood loss, one day hospital stay and earlier return to normal activity. The study also showed slightly improved potency outcomes in the robotic group after 12 and 24 months, although not statistically significant(12). Length of hospital stay after robotic prostatectomy is significantly shorter than after open radical retropubic prostatectomy As shown by Yaxley et al the mean hospital stay for open radical prostatectomy is 3 days and robotic prostatectomy mean hospital stay is 24 to 36 hours (<0·0001)(13).

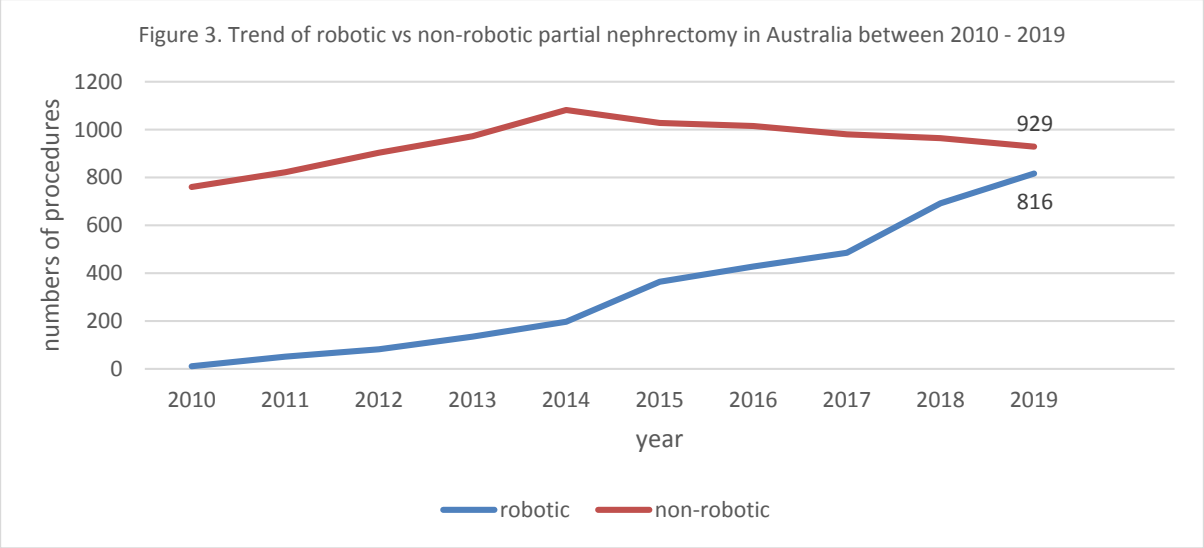
Improvements in quality of life outcomes provided by the robot relate to the three-dimensional, 10 times magnified view which allows better access to and improved vision of the neurovascular bundles which lie beside the rectum underneath the prostate. The robot also allows superb visualisation of the skeletal muscle of the striated sphincter muscle, which controls urinary continence. The ability to perform a sphincter preserving watertight anastomosis has meant that the stricture rate between bladder and urethra following radical prostatectomy has reduced from 16% to 1% after introduction of robotics(14). Some authors have reported alternative approaches to the robotic retropubic approach. The most commonly reported now is the Retzius sparing approach. In 2013, Galfano reported this technique, whereby the bladder is left suspended to the anterior abdominal wall and access to the prostate is achieved through a peritoneotomy posterior to the bladder and seminal vesicles(15, 16). Initial reports of this technique showed a high T2 positive margin rate compared with matched traditional robotic prostatectomy. Subsequently several series have been published(17-19). There is a trend to higher positive margins. The surgery is mostly reserved for those with low risk or intermediate risk prostate cancer. Menon reported that 12-month measurable outcomes were no different from his conventional matched series(20). The operation is challenging and is probably best performed in those centres where there is a high volume of robotic radical prostatectomy undertaken.



Source: Device Technologies Australia Pty Ltd(5), Australian Institute of Health and Welfare(21), Medicare Statistics(22), MBS Online(23)

Robotic partial nephrectomy

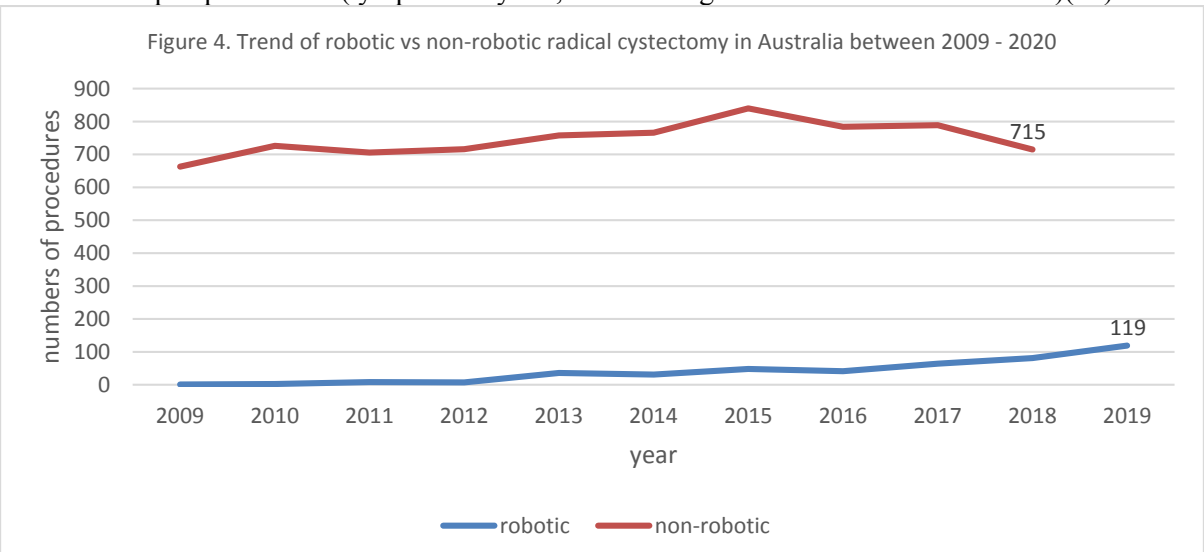
Partial nephrectomy using the robot (RAPN) has now become standard of care for small renal masses in those Australian hospitals possessing robots. Partial nephrectomy surgery has increased at a rapid rate. The ability to perform safe partial nephrectomy has allowed surgeons to offer less aggressive approaches to kidney cancer with the ability to preserve renal parenchyma. Recent studies confirmed excellent oncological outcomes for patients with tumours 4 to 7 cm treated with partial nephrectomy. These outcomes are similar to those reported in historical radical nephrectomy series for similarly sized tumors. Therefore, partial nephrectomy is an acceptable and often preferred treatment for renal masses >4 cm(24). The first RAPN in Australia was performed in 2010(25). There has been a steady yearly increase in numbers to 816 partial nephrectomies performed robotically in 2019 (Figure 3). In the past 10 years, 3743 robotic partial nephrectomies have been performed in Australia (5). The advantage of robotic surgery compared to a laparoscopic approach relates to a shorter learning curve and an easier renorraphy, with subsequent shorter ischaemia times associated with renal artery clamping. The reduced ischaemia time facilitates and improves preservation of the renal parenchyma. Robotic partial nephrectomy can also be performed on large and complex renal masses in the presence of a solitary kidney(26).



Source: Device Technologies Australia Pty Ltd(5), Australian Institute of Health and Welfare(21), Medicare Statistics(22), MBS Online(23)

Robotic radical cystectomy and urinary diversion

The operation of radical cystectomy and urinary diversion remains the most challenging in urology. Complication rates from open radical cystectomy over the years have been high and internationally, a 30% readmission rate for major complications is reported(27). Transitioning from open surgery to robotic cystectomy has been difficult. The surgery is lengthy and is best performed using two teams of robotic surgeons, one for the extirpation and the second for the reconstruction. Coughlan and his group from Brisbane reported a large series of robotic radical cystectomies with urinary diversion in this journal in 2019(27). Their outcomes compared to the historic outcomes showed equivalence in complication rates. The Brisbane team are experts (100–750) cases and super-experts (2100–3500 cases)in provision of robotic surgery(28). The operation probably should be performed in major centres where there is a concentration of experience in this procedure. This is mandated in the United Kingdom, where centres performing this procedure must perform between 20 and 50 per year. Since 2009, 532 robotic radical cystectomies been performed in Australia(5) with incremental increases each year (figure 4). In published series, there is equivalence in the oncologic efficacy between robotic and open procedures (lymph node yield, cancer margin status and recurrence rates)(29).



Source: Device Technologies Australia Pty Ltd(5), Australian Institute of Health and Welfare(21), Medicare Statistics(22), MBS Online(23)

Robotic Pyeloplasty, Nephrectomy, Nephroureterectomy

These, urological operations have been performed robotically with safety and efficacy. There is a potential advantage in robotic pyeloplasty over laparoscopic pyeloplasty, in the ability to perform reconstruction of the renal pelvis with much greater dexterity using robotic instrumentation than that with laparoscopic instrumentation(30). Robotic pyeloplasty is now the preferred method of performing this surgery in centres with a robot platform. Radical nephrectomy or simple nephrectomy operations are most commonly done laparoscopically currently. Although the consumable costs of laparoscopic and robotic nephrectomy are similar, the robotic approach is significantly more expensive to due the capital costs of the robotic system. There has been no published study to show benefit of the robotic approach over laparoscopic methods. There is oncologic equivalence between laparoscopic/robotic and open nephrectomy for T1-T2a tumors(31). If and when costs reduce it is likely robotic radical nephrectomy and robotic simple nephrectomy will become standard of care.

Miscellaneous Robotic urologic surgical procedures

Simple benign prostatectomy, adrenalectomy, ureteric reconstruction, ureteric reimplantation, Boari bladder flap reconstruction and retroperitoneal lymph node dissection have all been performed robotically. Robots have also been used in urology to perform gender reassignment surgery, renal transplant surgery and surgery for male infertility.

Future perspectives in Australia

The future will include robotic applications for almost all urologic surgeries. Before all this can occur, three major problems remain in Australia. First, provision of robotic technology in the public system where surgical training is performed. Secondly, development of a robotic education curriculum for trainees has to be implemented. Finally, the problem remains of the high cost of machines and instruments. Costs will reduce in the next 24 months due to significant competition from at least three new robotic surgery companies to the existing monopoly vendor.

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