Royal Australasian
College of Surgeons

Robot-Assisted Surgery Working Party

Final Report and Recommendations

ROBOT-ASSISTED SURGERY WORKING PARTY
FINAL REPORT AND RECOMMENDATIONS

1. BACKGROUND

Since the introduction of the first surgical robotic system into clinical practice in Australia and Aotearoa New Zealand in 2003, there has been an exponential uptake of robotic platforms by a broad range of surgical specialities. The Robot-Assisted Surgery Working Party for this report has made a conscious pragmatic decision to direct the focus to those systems where the surgeon is in control of the interactive components of the robot platform via an operating console, such as those used in Urology, Gynaecology and Colorectal procedures. It is important to recognise that this report does not cover the robotic guidance systems such as those that have emerged in orthopaedic and neurosurgical applications as examples.

Data provided to the Robot-Assisted Surgery Working Party from Device Technologies, vendor of Intuitive da Vinci robotic platforms, reveals procedure growth from a handful in 2004, < 4,000 in 2012, to nearly 20,000 in 2022, totalling over 120,000 procedures since 2003[1]. The use of robotic platforms varies across different surgical disciplines and at different stages of maturity. Apart from issues of access, robotic assisted surgery has particularly established itself in the fields of urology, gynaecology and colorectal surgery. This rapid growth necessitates similar growth in training standards and programs to ensure there are sufficient practitioners qualified to utilise this approach and do so safely[2].

As of May 2023, there are 162 robotic platforms used for surgery across Australia and Aotearoa New Zealand. One of the most significant barriers we see to robot-assisted surgery (RAS) access arises in the public sector; 136 platforms are located in private hospitals, with 26 in public hospitals. The distribution of robotic platforms in Australia significantly favours metropolitan centres, with only 14 platforms in rural and remote hospitals and 139 platforms located in metropolitan hospitals. The distribution of robotic platforms in Aotearoa New Zealand also favours metropolitan centres, with one platform in rural and remote hospitals and eight platforms located in metropolitan hospitals[1]. Data provided to the Robot-Assisted Surgery Working Party from Device Technologies, the local distributor of Intuitive da Vinci robotic platforms, has shown a 12 per cent increase in the number of procedures performed on da Vinci platforms from 2021 (17,852) to 2022 (19,989) in Australia and Aotearoa New Zealand. Urology is the specialty with the greatest usage (63 per cent), followed by General Surgery (17 per cent), Gynaecology (15 per cent) and Head & Neck, Cardiac and Thoracic surgery (a combined 5 per cent). The greatest growth from 2018 to 2022 is seen in General Surgery, primarily in colorectal procedures[1].

Figure 1a. Device Technologies robotic procedures by specialty

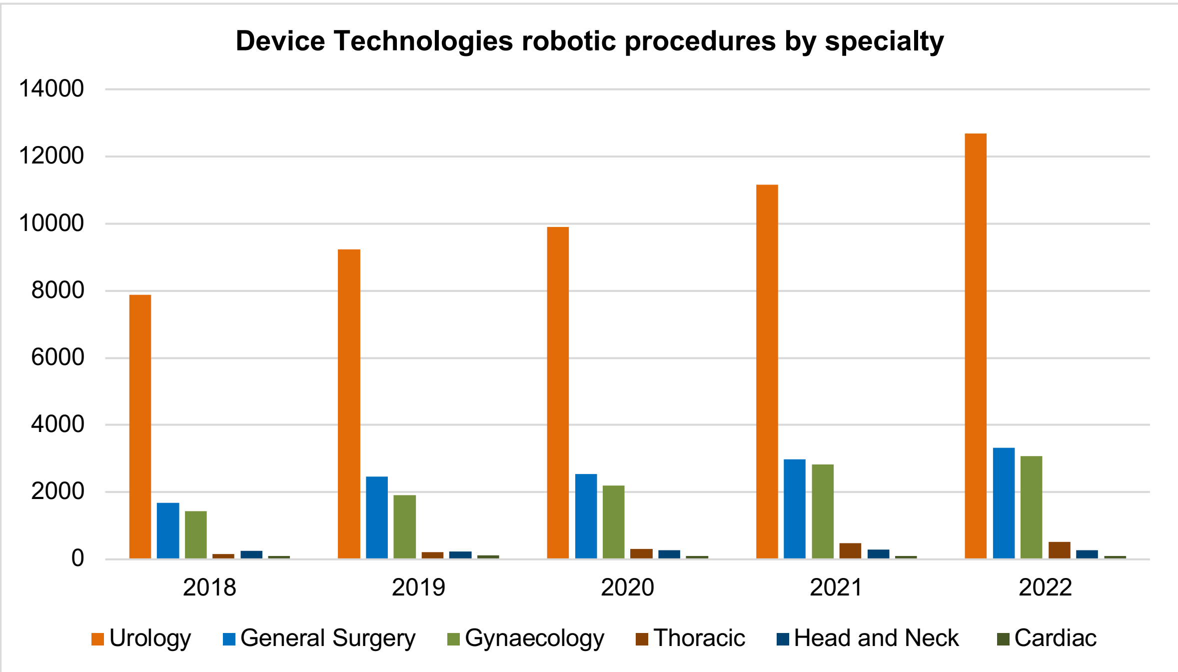


Figure 1b. Device Technologies robotic procedures by specialty

	2018	2019	2020	2021	2022
Urology	7,871	9,231	9,904	11,151	12,687
General Surgery	1,687	2,470	2,546	2,988	3,319
Gynaecology	1,435	1,913	2,196	2,833	3,080
Thoracic	152	206	309	490	523
Head and Neck	256	239	278	283	272
Cardiac	95	110	101	107	108
TOTAL	11,496	14,169	15,334	17,852	19,989

This is a snapshot of the current state of RAS; it is the consensus of the working party that wide-scale adoption of RAS is likely.

Since the introduction of the da Vinci Surgical System in 1999[3] robot-assisted surgical platforms have evolved in design and functionality, from console style, robot carts and the number of arms, enhanced imaging capabilities, haptic feedback and the degree of freedom for arms and instruments. We expect further advances in the future, including the introduction of artificial intelligence (AI) and additional feedback systems to operating systems, as a result of collaborations between innovative surgical companies [4].

In Australia and Aotearoa New Zealand, there are no established curricula for RAS training, which is mainly overseen by the RAS system manufacturers and vendors[5]. With robotic systems being increasingly installed in hospitals, there is a need to further consider using these technologies, as well as develop appropriate curricula for surgeon training and assessment to minimise the impact of learning curves on patient outcomes[6][7].

In 2020, the Royal Australasian College of Surgeons (RACS) participated in the National Workshop for Surgical Robotics[8] to review aspects of RAS in Australia, including data collection and characteristics of training and credentialing. These discussions highlighted uncertainties regarding RAS in Australia and Aotearoa New Zealand:

- RAS has entered surgical practice with no standardised training and credentialing, and the satisfactory training and credentialing requirements are unclear.
- RAS can be applied to a wide range of procedures. However, the clinical outcomes of RAS are unclear. As a result, it is uncertain which procedures RAS can be considered an option for standard care[9].

The challenges with robot-assisted surgery are not only complex procedures, but also which robotic platform is used for the surgery. With so many surgical modalities available, it will likely come down to specialty groups partnering with industry to set guidelines based on the complexity of procedures and the abilities of the technology used. There will not be a one-size-fits-all approach.

Things change quickly in our industry; Australia is behind the rest of the Western world regarding access to robots in public hospitals. The public deserve, however, to be assured that use of robots is restricted to appropriately trained and credentialed surgeons.

There has been greater uptake of robotic platforms in North America due to vendors selling directly to hospitals. Like most international markets, Australia and Aotearoa New Zealand acquire robotic platforms through locally appointed distributors. Consequently, uptake has been impacted as cost is both prohibitive and a barrier to entry, especially in public hospitals. While adoption of RAS may be in its infancy in some centres of Australia and Aotearoa New Zealand, and outside the private sector, it is now an international standard of care for many procedures.

There is a clear demand from Trainees globally for robotic training opportunities, who see the future of their specialty involving robotics. For example, in a survey of UK surgical Trainees, 77 per cent felt robotic surgery should be integrated into training[10]. Robotic availability is increasing and the future into which new consultants will emerge is a robotic landscape; integrating robotic training at an earlier stage will help to ensure they are ready to use the available technology appropriately and proficiently. With the original introduction of laparoscopic surgery, the initial focus was on upskilling consultants, but soon became common practice and an integral part of training. This is the likely trajectory for RAS.

With the increasing adoption of RAS, it has already been observed that training posts that offer RAS exposure tend to be the most sought after by SET Trainees in Australia and Aotearoa New Zealand. This appears to be even more so with the choice of post-Fellowship training positions where RAS training is considered to be of increasing importance. At the completion of post-Fellowship training, the ability to practise the learned skills is limited by the availability of the technology.

Internationally, other jurisdictions are beginning to integrate robotic training into their training pathways. It is important for RACS to keep up with emerging technology and ensure patients in Australia and Aotearoa New Zealand are operated on by a skilled, technology-ready, safe surgical workforce.

The Robot-Assisted Surgery Working Party was established in June 2022 to explore the place of RAS in clinical practice and associated education and credentialling. The Terms of Reference are outlined in **Appendix 1: Terms of Reference**.

2. SAFETY AND EFFICACY

Surgical robot systems aim to provide a safe and more effective RAS platform for patients and surgeons. The safety and efficacy of robot-assisted surgery will vary per procedure; some procedures are well documented to be safe and efficacious, while others are less commonly practised. Alternative standardised procedures, if available, should always be discussed and offered to patients.

While the U.S. Food and Drug Administration (FDA) has cleared RAS devices for use in certain types of surgical procedures commonly performed in patients with cancer, such as hysterectomy, prostatectomy and colectomy, as recently as August 2021 the FDA issued advice reminding patients and healthcare providers that the safety and effectiveness of robotic devices for long-term benefits is still to be established, and recommended that patients and healthcare providers discuss the potential risk benefits and alternative surgical options in order to reach a patient-informed treatment decision[11]. Conversely, equivalent or superior outcomes are demonstrated for prostatectomy and ventral hernia procedures.

Appendix 2: Randomised controlled trials (RCT) contains overviews of randomised controlled trials across specialties comparing RAS to laparoscopic surgery. There is evidence from propensity-matched studies showing the benefits of RAS compared to open surgery, but less so when compared to laparoscopic. However, RAS facilitates completing the procedure minimally-invasively and is thus favoured over laparoscopy due to the advantages of the technology. Note that most of these RCTs compared to laparoscopy and not open surgery, as surgeons favour the use of robotic platforms for minimally invasive surgery.

Efficacy largely depends on the control group. When compared to laparoscopy, the benefits are less clear but when the established procedure is open, for example a major hepatectomy, RAS can facilitate a minimally invasive approach and provide benefits. Sometimes, laparoscopy and RAS are used in unison, for example in laparoscopic dissection, robot reconstruction in a Whipple procedure, so the technologies aren't mutually exclusive. Equivalent outcomes can be thought of as being obtained despite the limitations of laparoscopy and facilitated by the advantages of RAS.

2.1. Is robot-assisted surgery a cost-effective modality of operative intervention?

Cost effectiveness is difficult to measure, as with multiple vendors currently in the market, and others poised to join soon, the data is changing. Competition between manufacturers and vendors, and the cost of consumables, is causing disruption in the industry. Due to the financial investment required to acquire robotic platforms and establish operations, hospitals will need to achieve economies of scale in order for this surgical approach to be cost-effective.

Technological advances, such as robotic surgical platforms, are an industry enhancement and require financial investment to be properly established. Therefore, the focus should move away from cost equivalence and more towards an acceptance of increased costs provided that there is evidence of benefits being realised.

2.2. What data should be systematically collected to monitor and evaluate safety, efficacy and cost-effectiveness?

A minimum dataset is required for the purposes of assessing surgical performance, including how surgeons compare relative to other surgeons, and comparing robotic procedures with non-robotic procedures. Comparison data allows us to track better patient outcomes and procedures that cannot be done conventionally. We anticipate that this data will be different for each specialty as some metrics will show consistent improvement over time, while others will provide useful planning information over time.

The suggested data set would provide an opportunity to evaluate retrospectively or implement an audit cycle and contains passive data that is available in computer systems, medical records and basic metrics that hospitals are already mandated to collect. The data set is common across the industry and does not contain procedure- or specialty-specific data; it is the responsibility of the specialty societies and boards to set these standards for data collection. The value of robotic procedures varies across each specialty; therefore, data will need to be sub-specialised.

The following figure details a suggested minimum data set for collection and is based on the Grampians Health Robotic Technology Training Program (RTTP) funded by the Department of Health (Victoria).

Figure 2. Suggested minimum data set for collection

Suggested minimum data set for collection	
Step 1: Data extract	Hospital (UR) number
	Procedure code(s)
	Robotic surgery code(s)
	Length of stay
	Complications
	Unplanned readmission < 30 days of index admission
	Unplanned ICU admission
	In-hospital 30-day mortality
Step 2: Operating Room collected process measures to assess the impact of the robot on theatre time	Surgeon, presence of proctor and robotic procedure number
	Time for draping and docking the robot
	Time for engagement and disengagement with the robot
	Duration of surgery
	Duration of anaesthesia
	Room turnover time
	Instruments used and cost of disposables used for surgery
	Blood loss
	Positive margin rates
	Unplanned conversion rate
Step 3: Standardised clinician experience questionnaire	
Step 4: Standardised ergonomic assessments, including REBA and RULA	
Step 5: Experiences of receiving care questionnaires, including EQ5D, PROMS and PREMS	
Step 6: Details of robot malfunction incidents to be provided by vendor	

It would be valuable to capture data covering the lack of access to robots i.e., comparing procedures that would have been done better or quicker robotically, but were not able to for certain reasons, such as robot unavailability. There are also several procedures that currently have no comparison data, but in future could be compared retrospectively.

2.3. Consumer considerations and concerns

Members of the public in Australia and Aotearoa New Zealand traditionally place great faith in the quality and safety of the medical and surgical care provided, knowing that surgeons are credentialed and undergo a rigorous training program. Generally, the cost of procedures is a lesser concern in the Australian and Aotearoa New Zealand healthcare systems provided outcomes are as efficacious as possible. The public needs to be able to continue to hold this faith in the safety of new procedures and techniques as they are introduced. Recent media attention focused on 'cosmetic surgery' has highlighted to the public the need to ensure that the health professional they entrust with a procedure has undergone appropriate training and credentialing. Public trust in surgeons and health services can be undermined by a succession of negative media reports; these tend to highlight 'worst case' scenarios and outcomes.

RACS and the professional societies representing surgical specialty societies deliver Australian Medical Council (AMC) and Medical Council of New Zealand (MCNZ) accredited training programs which enable surgeons to become recognised specialists. By the time they are accredited, registered surgeons have undertaken a minimum of 12 years medical and surgical education, including at least five years of specialist postgraduate training, and are formally recognised as Fellows of the Royal Australasian College of Surgeons, using the FRACS post nominal. Australian Health Practitioner Regulation Agency (AHPRA) have made a decisive regulatory decision to protect the title 'surgeon' in the national law[12]. The use of the title 'surgeon' will be restricted to only medical practitioners holding registration in the specialties of 'surgery', 'obstetrics and gynaecology', and 'ophthalmology'[13]. Former RACS president Dr Sally Langley said the decision was a welcome one and would add an important layer of safety when it comes to patients choosing a surgeon; "Restricting who can use 'surgeon' will help prevent patients from undergoing surgery under a false assumption about the standard of training of the person carrying out the surgery. It will also help maintain public confidence in the high standards of our health system"[13].

Another important stakeholder to consider are surgeons. The Wellbeing Charter for Doctors aims to define wellbeing and describe the principles that guide the wellbeing of doctors in Australia and Aotearoa New Zealand[14]. The Charter also describes the shared responsibility of wellbeing for the medical profession, including a requirement to prepare in advance for the changes that punctuate a career in medicine. RAS allows for better ergonomics for the surgeon as less strain is put on the body when operating. With an ageing workforce, use of robotic consoles may extend the working life of a surgeon. If the use of RAS can extend the working life of a surgeon, it has important workforce implications through the intellectual capital provided from senior surgeons. Moreover, there will be a disproportionate benefit on the surgical capital in regional, rural and remote regions as it will allow the most experienced and senior, and thus potentially most able, surgeons to work for longer.

2.4. Risks and safety advantages of robot-assisted surgery

There are adverse effects specific to individual procedures, however the focus of this report is to examine the general risks that are often common to many RAS procedures. Risks of RAS can be broadly divided into:

I. general surgical risks; haemorrhage, tissue / organ injury, infection, CO_2 related complications and venous thromboembolism (VTE)

II. risks unique to the use of robotic system including;

   a. robot malfunction or crash down in the middle of the surgery,

   b. robotic arm collision with theatre nurse or assistant, its own arms and the patient,

   c. mechanical and electronic devices failure, patient positioning-related risks including upper and lower limb nerve injuries particularly in high BMI patients and prolonged >240 min operative time,

   d. difficulty in patient repositioning during surgery,

   e. tissue damage, needle breakage or instrument damage due to loss of haptic feedback,

   f. communication delay or barriers due to the physical separation between the surgeon sitting at the console, the assistant, the anaesthetist and the patient.

III. anaesthetic risks related to invasion of anaesthesia workspace by robot making the patient inaccessible intraoperatively[15,16,17]

In addition to delivering the benefits of minimally invasive surgery, such as smaller incisions, reduced need for postoperative analgesia, and decreased length of stay, RAS offers unique technical advantages to the surgeon over and above traditional laparoscopic surgery including:

I. Total autonomous camera control

II. Three-dimensional vision

III. Higher magnification

IV. Elimination of fulcrum effects

V. Instruments with wrist-articulated 7-degree of freedom movement

With the elimination of physiologic tremors, the increased dexterity of the robotic instruments, greater degrees of freedom[18], the opportunity to sit while operating, evidence showing lower muscular workload and improved ergonomics, RAS may reduce work-related musculoskeletal disorders (WMSD) of surgeons, and improve safety to individual patient and benefit the wider community from extended access to the intellectual and clinical experience of experienced surgeons, and cost-savings associated with training surgeons[19,20,21].

3. SURGICAL EDUCATION AND TRAINING

RAS provides both a unique challenge and an opportunity in surgical training and education. It is essential to train the current Trainees and surgical workforce with the required skill set to perform RAS as it expands in clinical practice. This necessitates simultaneous training for multiple levels of learners as both pre- and post-SET Trainees adopt approaches to RAS.

It is recommended that RAS training should commence for Trainees during the SET program. It is interesting to note that RAS is part of the core curriculum of the American Urological Association and is beginning to be offered as part of the training program for the Royal College of Surgeons in Ireland[22] and the proposed surgical pathway for Royal College of Surgeons of Edinburgh[23].

3.1. Challenges and opportunities

It is important to acknowledge the challenges and opportunities for training and education in RAS. Challenges include cost and duration of training, availability of proctors and trainers, the impact on laparoscopic and/or open surgery skills, multi-platform environments and inequity for regional, rural and remote Trainees and surgeons. There are two emerging challenges that we face as a result of the rapid expansion of RAS. The first is the risk that inadequate exposure and training in RAS during SET could see our Trainees considered less competitive for prestigious post-Fellowship positions in centres where RAS has advanced with universal adoption. The second is that surgeons who have gained experience in RAS during post-Fellowship training will seek to work where RAS technology is in place. This has the potential to create even greater difficulties for rural and remote regions in attracting and retaining a surgical workforce. Opportunities include training multi-level learners, use of simulation and synthetic organ models, use of video-based review as a training and proctoring tool and credentialing criteria based on competency rather than case numbers.

The opportunity cost of performing cases using robotic platforms should be recognised, as initially the cases are likely to be less complex and performed by consultants. For a Trainee, adding RAS to a training program may compromise laparoscopic experience during foundation years. The introduction of RAS has the potential for reduced operative experience for Trainees, affecting senior Trainees in particular, as consultants move away from other techniques. This is overall unlikely as in many procedures laparoscopic and robotic surgery are used interchangeably. The notion of ‘learning it open first’ should also be curtailed.

Curriculum design is crucial to program success, but it is imperative to consider how the training program will be delivered. Despite enthusiasm for the platform, access to robotic platforms is a limiting factor in training, which necessitates consideration of maximising the efficiency of platform opportunities. RAS requires complex and expensive equipment, and the associated costs have made training delivery unfeasible in many facilities. Determining the types of procedures and the number of surgeons performing them is a significant undertaking and is outside the remit of this working party. Faculty will also need to be recruited, trained and maintained. At present there is a critical shortage of faculty for existing RACS courses, thus, use of endorsed third-party education providers may provide a solution to this issue.

Current vendor-delivered RAS training is only offered for a single platform. An opportunity exists to develop multimodal, platform-agnostic training resources to assist surgeons to safely transition between platforms as multi-platform environments will become more common in the coming years.

3.2. What would best-practice education and training in robot-assisted surgery look like?

Developing RAS training provides the opportunity to create a modern, evidence-based training curriculum. RACS Education Development and Delivery team follow the outcomes model, as outlined in the ABC of Learning and Teaching in Medicine: Curriculum Design[24] when designing a new curriculum. This model was applied when developing the RACS Professional Skills Curriculum, and asks four important questions:

- What educational purposes should the institution seek to attain?
- What educational experiences are likely to attain the purposes?
- How can these educational experiences be organised effectively?
- How can we determine whether these purposes are being attained?

An equally important part of the curriculum development process is working with subject matter experts who guide the development of the curriculum according to the reality of their clinical practice and workplace-based experience.

The following figure outlines a graphic representation and proposed template for robot-assisted surgery education and training involving multiple components. This is an ideal pathway for consultants adopting RAS. As training pathways evolve, a pragmatic approach may necessitate some steps happening in parallel or out of sequence for Trainees under supervision.

Figure 3a. A proposed template for robot-assisted surgery education and training

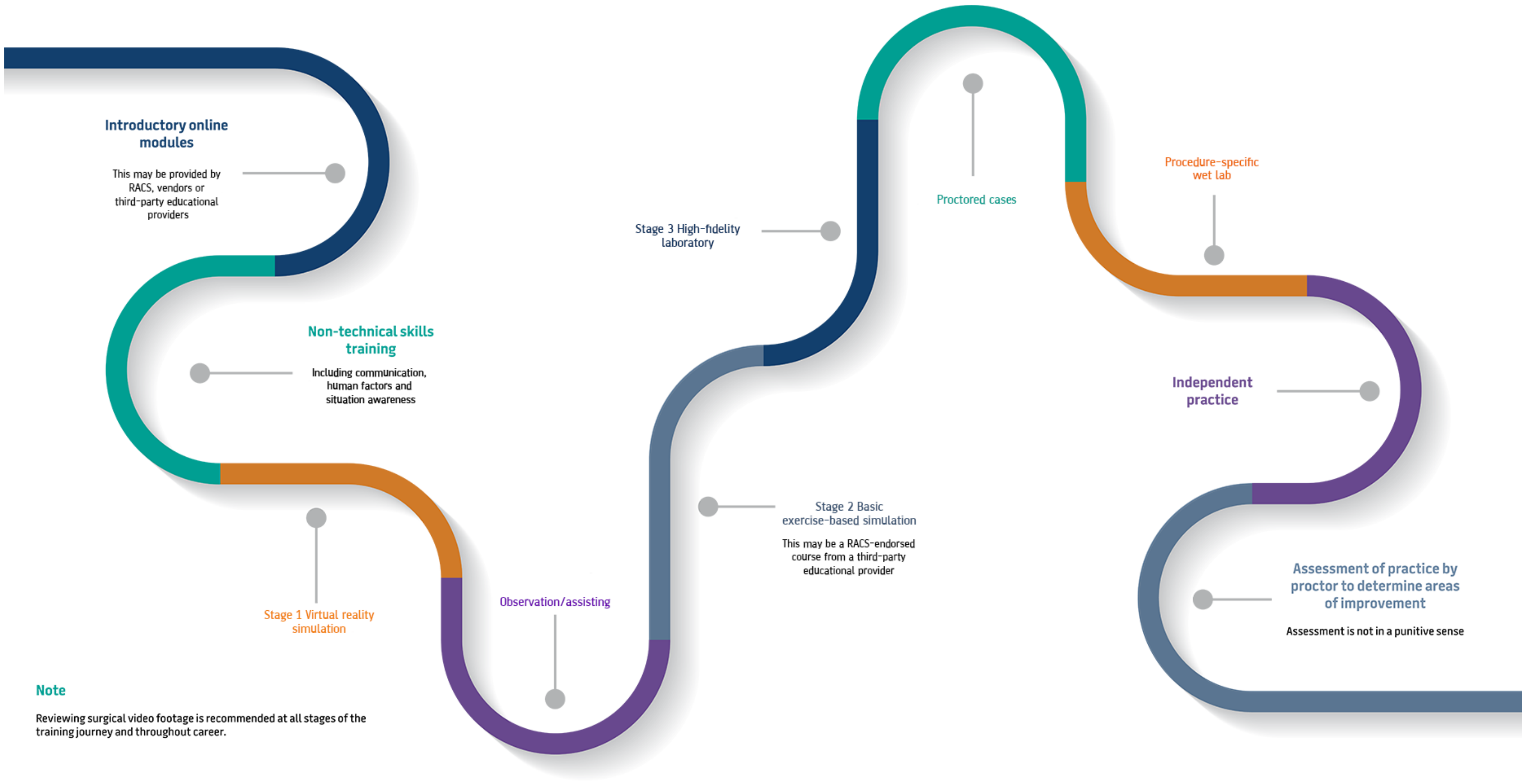


Figure 3b. A proposed template for robot-assisted surgery education and training

Introductory online modules This may be provided by RACS, vendors or third-party educational providers
Non-technical skills training Including communication, human factors and situation awareness
Stage 1 Virtual reality simulation
Observation/assisting
Stage 2 Basic exercise-based simulation This may be a RACS-endorsed course from a third-party educational provider
Stage 3 High-fidelity laboratory
Proctored cases
Procedure-specific high-fidelity laboratory
Independent practice
Assessment of practice by proctor to determine areas of improvement Assessment is not in a punitive sense
Note: Reviewing surgical video footage is recommended at all stages of the training journey and throughout career.

The use of video review of RAS cases throughout a surgeon's training journey and career is endorsed by the working party. Ideally, videos should be of educational value and break down the procedures into procedural steps, with a focus on quality rather than completion of a set number of videos. This can be in the form of peer-reviewed video in journals or from third-party education providers who collate specifically designed educational videos. Video review may be facilitated by an individual surgeon, within a team or working group at a hospital or using a dedicated platform. Continuous learning through video review is encouraged as surgeons progress through their career.

Some RAS manufacturers also provide apps for surgeons to track their performance on a platform, passively collecting data to analyse and benchmark performance against other surgeons, whilst simultaneously tracking a procedure-specific learning curve[25].

There will be an increasing necessity over the coming years to provide multi-platform, or cross-console, training as more hospitals invest in RAS infrastructure, thus providing more opportunities for surgeons.

It is important to note that the curriculum recommendations provided are applicable to RAS broadly, with the understanding that there is a common skill set to be learned during the SET program, such as platform familiarity and index procedures, before procedural and specialist aspects of training are consolidated in dedicated post-SET programs. It would be the responsibility of the specialties and subspecialties to refine these curriculum suggestions for their specialty- and procedure-specific requirements.

3.3. Who should deliver and govern training in robot-assisted surgery?

Currently, manufacturers and vendors of robotic surgical systems provide education and training courses, and credential users who complete them. There has been an absence of independent RAS training pathways, which necessitated a pragmatic acceptance of vendor-led training until surgeons themselves became trainers and offered embedded training models within institutional settings. This has allowed the first wave of surgeons to train a second wave within their institutions and is akin to more traditional approaches of teaching surgery via a mentor-mentee model. Recently, there has been an emergence of surgeon-led educational organisations which offer alternative RAS curriculum pathways and training materials independent of industry.

Surgeon-led, standardised, independently accredited curricula that incorporate validated educational practices are paramount to ensure surgical competence in using RAS, thereby minimising potential risks to patients. Surgeons who undertake educationally sound, independently accredited training programmes will not only have greater competence in conducting RAS but are better placed to contribute to the growing evidence base on new technologies, ensuring outcome metrics are reliable and relevant.

Currently, RACS is responsible for the delivery and governance of surgical training to meet the standards for Fellowship. Sub-specialised training, delivered post-FRACS, is the scope of specialised and sub-specialised bodies, while in some instances ultra-specialised training is institution-led such as UC Davis Medical Centre who recently performed the first robotic nephrectomy on a living kidney donor[26]. If RAS becomes part of the FRACS curriculum, its delivery and governance would become part of RACS purview.

3.4. Who would qualify to instruct / train in robot-assisted surgery?

RAS is a tool to be used to perform surgery, therefore, the principles of training should be aligned to complement current training practices.

RAS requires complex and expensive equipment, and the associated costs may limit the number of facilities where it is feasible to successfully deliver courses. Faculty will also need to be recruited, trained and maintained. At present there is a critical shortage of faculty for existing RACS courses. Third-party education providers may be prepared to invest in training infrastructure to provide this training, with the associated costs directly passed on to course participants. Situations may arise where it is appropriate and beneficial for RACS to partner with or endorse the offerings of third-party education providers.

While clinical training within RAS must remain in the hands of surgeons, some components of preclinical training may not require the trainer to be a surgeon. This already occurs in industry-led programs where industry-trained staff play an important role in the preclinical stages of training. For example, one manufacturer has frequently used former military personnel for high-fidelity laboratory training, and an independent educational provider engages an aviation trainer to teach non-technical skills and situation awareness. Both have proven these to be viable models with practical approaches to provide what the industry requires.

There is a significant time commitment required from surgeons who teach intensive RAS training, who are already a time poor profession, and who forgo their own clinical work and earnings in order to teach. Currently, industry dictates that a surgeon must complete a set number of RAS cases before they are fit to teach it, however, access issues across the industry may make case volumes an unfair indicator of teaching capability. Competency and interest and experience in surgical training should be given more weight as indicators of teaching capability and suitability.

It would be practical to define proctors at the procedure-level. This would increase the number of proctors available to teach straightforward cases and fewer for complex cases, ensuring adequate surgical capital across regions. With a shortage of available proctors, a model for proctorship may involve video review technology. Remote mentoring would also allow experts to transfer knowledge to less experienced individuals in an educational or clinical setting. It would reduce costs, address the shortage of trained experts, and overcome geographic limitations (and other causes of reduced educational opportunities such as the COVID-19 pandemic)[2]. Video and tele-presence platforms would facilitate remote surgical education, enabling real-time virtual guidance and training[27] and proctoring.

3.5. Who should determine the educational content?

Specialty training boards are responsible for developing the curriculum of the Surgical Education and Training (SET) program to transform Trainees from novice to competent and proficient surgeons, as assessed against the ten RACS competencies. The specialty training boards are also responsible for the regulation and delivery of the Surgical Education and Training (SET) program which includes curriculum and content of training, assessment of satisfactory completion of training and maintenance of surgical standards in each specialties' SET training program.

RACS, through the Committee of Surgical Education and Training (CSET) and Education Committee, can provide guidance for both general and overarching RAS curriculum and required educational content, however specialty-specific guidance should be provided by the respective specialty training boards and sub-specialty organisations. Due to the infrastructure and establishment costs associated with curriculum development, where appropriate, independent third-party education providers may also be engaged to contribute to components of a proposed RAS curriculum.

3.6. Who should set the standards of education and training?

The standards of education and training for RAS incorporate two aspects; standards of course content and delivery, and standards of Trainee performance.

CSET is responsible for the regulation and administration of the nine RACS Surgical Education and

Training (SET) programs in Australia and Aotearoa New Zealand. CSET is accountable to RACS Council through the Education Committee[28]. CSET and the Education Committee ensure that education standards are consistent with RACS education programs and other endorsed programs, while specialty training boards are responsible for standard setting activities for their respective specialty curriculum.

The specialty training boards are responsible for the regulation and delivery of the SET program which includes curriculum and content of training, assessment of satisfactory completion of training and maintenance of surgical standards in each specialties' SET training program. As RAS is competency-based, Trainees must be provided the opportunity to demonstrate proficiency-based progression. This will likely require work-based assessments and/or a logbook to capture satisfactory completion of training and assessment.

The standards of education and training for RAS must be consistent with practices that RACS endorse across training programs. RACS staff within the Education Development and Delivery team are qualified to review content and delivery modes and have worked with RACS specialties and third-party education providers to ensure their content is consistent with RACS standards and practices.

3.7. What are the graduate outcomes of training in robot-assisted surgery?

Graduate outcomes are 'statements that describe the standard of performance expected by the end of a training program'[29]. To guide Trainees' progress through the three stages of the SET program, learning and graduate outcomes for each of the eight professional competencies are identified in the Professional Skills Curriculum, while the two technical competencies (medical expertise and technical expertise) are identified in the curriculum for each specialty. These learning and graduate outcomes are aligned to the behavioural markers expected of Fellows as outlined in the RACS Surgical Competence and Performance Guide[30].

Graduate outcomes for the medical expertise and technical expertise competencies in relation to RAS will vary for each specialty, and as such should be managed within their respective curricula.

There is an expectation that surgeons who train in RAS following Fellowship should have the same outcomes as graduates.

3.8. Should training commence before, during and, or after SET?

When considering the industry that current SET Trainees will graduate into, it makes sense that a level of RAS training will be incorporated into SET. Currently, the majority of RAS training is provided post-SET. It is inevitable that RAS will move into SET, with some elements incorporated into pre-SET. While some platforms are still in their infancy, we must consider the stage of introduction and that the role of SET training in specialties will change in the coming years. As with all skills, the optimal way for surgeons to be trained in RAS is to have consistent access from pre-SET through post-SET, rather than at a single, mid-point of the surgeon's career where it must be acquired as a new skill.

As the operative curriculum is so broad, a pragmatic aim for Trainees may be familiarity with the platform and competency in index procedures during the SET program with more procedural and specialised aspects of training being consolidated in dedicated post-SET and post-Fellowship programs. Pre-platform training, basic knowledge and skills training should be followed by advanced procedure-specific training[2]. This would closely mirror current training in sub-specialty surgery and how advanced laparoscopy is taught. It is important to recognise that RAS will become more integrated into pre-SET training as interest grows in the Junior Doctors (JDocs) space.

One option would be to run a basic College-endorsed course similar to Australian and New Zealand Surgical Skills Education and Training (ASSET) or University of Western Australia's Clinical Training & Evaluation Centre (CTEC) core skills courses in Foundation and Intermediate Laparoscopic Surgical Skills[31]. This would ensure baseline familiarity with RAS and actively support senior Trainees who express an interest (SET 4/5) in RAS through the provision of dedicated training provided through vendors and third-party education providers. This approach may have the potential for significant uptake, however, as the majority of Trainees are likely to subscribe due to fear of missing out.

It is important that Trainees, Fellows and consultants are supported to develop their skills and safely adopt robotic surgery. As there are many consultants and mid-career surgeons still beginning their robotic journey, this necessitates an approach that trains multi-level learners in parallel.

3.9. How should education and training be resourced, funded and accessed?

Currently, manufacturers and vendors of robotic surgical systems provide education and training courses directly to surgeons. There are also multiple third-party education providers which provide robotic surgery education programs to educate and upskill surgeons, with access to TGA-approved robotic platforms.

There are concerns that industry funding will create conflicts of interest. An alternative user-pay option will put additional stress on Trainees, as the SET program is expensive, particularly given the requirement to complete additional mandatory courses during this time.

A hybrid model may be a more effective and realistic approach to implement. At the inception of RAS in Australia and Aotearoa New Zealand vendors paid for training and mentoring however over time the cost has shifted to the learner. As more competition emerges in the market, this may encourage greater contributions from vendors to support education at their cost in other international models, training of surgeons is heavily subsidised by the Government. An example of a large-scale partnership for a hybrid model has been established in the UK, where a manufacturer, Intuitive Surgery, has entered into an agreement to provide RAS training to surgical Trainees across north-east England [32]. While it is beyond the scope of this working party, it is a reasonable aspiration for RACS to seek structured funding for future RAS training. An opportunity may present itself for volume discounts or industry subsidising from alternative funding sources.

3.10. Training multi-level learners

With the absence of universal deployment of RAS in training hospitals, we cannot assume that young surgeons are starting with the same levels of RAS knowledge, experience and proficiency as exposure of SET Trainees to robotics will be highly variable. Until RAS deployment is standardised across all hospitals, we should expect a system of multi-level learners with varied exposure to RAS.

Multi-level learners can be classified as the following:

- SET Trainees with no experience
- Qualified surgeons with limited or no robotic experience
  - may have significant laparoscopic experience with intended procedures
  - may have significant open experience with intended procedures
  - may have significant laparoscopic and open experience with intended procedures
- Qualified surgeons with exposure to RAS training through SET experience
- Qualified surgeons with post-FRACS Fellowship RAS training
- Specialist International Medical Graduates (SIMGs)
- International Fellows

International Fellows and SIMGs will likely sit at an equivalent level of those other categories of multi-level learners. It is important to recognise that restricting robotic access to post-FRACS will remove many international Fellowships in Australia and Aotearoa New Zealand, as RAS training opportunities are a major driver for Fellows coming to Australia and Aotearoa New Zealand. To continue to attract international Fellows and remain a world leader in surgical education and training, whilst ensuring access for Australian and Aotearoa New Zealand Fellows to international Fellowship opportunities, this must be a two-way consideration.

3.10.1. Multi-level training considerations

A focus on quality rather than quantity of training is important when training multi-level learners. We can ensure all surgeons have a basic understanding of the foundations of RAS, provided through online training, and work to increase hands-on training opportunities going forward as RAS becomes more widespread.

Logbooks should accurately reflect experience with minimally invasive surgery approaches, including laparoscopy. The ability to record component operating and simulation hours is important to log maintenance of skills and to augment clinical volume in the absence of access to cases. The ability to reflect component operating in logbooks is an important consideration from a training perspective, during team discussions at the commencement of a case and to ensure that all roles are clearly defined.

Surgeons with extensive experience in either laparoscopic or open approaches to the intended RAS procedures may master them quicker than those with limited experience. A systematic review of transfer of open and laparoscopic skills to robotic skills has shown that skill transfer from both approaches is most evident when advanced robotic tasks are performed in the initial phase of the learning curve, however there are limitations in existing literature[33]. The same review concluded that there is a role for systematic RAS training to include both basic and advanced tasks regardless of a surgeon's prior laparoscopic experience[33].

With the absence of universal deployment of RAS in training hospitals, exposure of SET Trainees to robotics will be highly variable. Additionally, if their mentors are qualified surgeons in a learning phase of their own robotic experience, that will likely diminish the Trainees' exposure to, and acquisition of robotic skills. This issue will decrease over time as greater numbers of surgeons become experienced with RAS.

Multi-level learning can be achieved by embracing component operating. Component operating has already been described as an effective way to train multi-level learners in robotic colorectal surgery[34,35]. Breaking operations into components and defined procedural steps is useful in planning for component operating. It is also beneficial to consider the complexity of the operation[36] to adjust component operating as required.

A multi-modal approach can be tailored and adapted to multi-level learners and should utilise modalities of simulation. By using component operating it is possible to train multiple Trainees simultaneously. When training multiple learners simultaneously, adoption of a component approach is of value[37]. Breaking procedures down into defined components and moving towards a consistent nomenclature around component operating may be useful for standardisation of training. This has also been termed the 'tri-section method' where the procedure is broken up into different steps for different learners[38]. Consideration of component operating is required when defining the 'primary operator' for logbooks in surgical training, with acknowledgment of component operating as an important primary operator task[38].

3.11. Current curriculum approaches

Current RAS curriculum approaches contain similar components, including a multimodal approach of online courses in basic robot-assisted surgery, use of simulators for basic skills exercises and advanced simulation in high-fidelity laboratories. These components are designed to develop cognitive and psychomotor skills to ensure safe robotic surgical practice[33]. Some programs, such as the proposed surgical pathway for Royal College of Surgeons of Edinburgh[39], also include a non-technical skill set incorporating communication, human factors and situation awareness.

3.11.1. Online courses

There are a number of existing online courses covering the foundations of robotic surgery, developed by third-party education providers, surgical societies and organisations and vendors. Internationally, there are also a number of simulation centres that have developed robotic surgery curricula and training programs.

3.11.2. Simulation and virtual reality

Simulation plays two key roles in robotic surgery training. The first role is to master technical control of the robot, and to develop familiarity with both the system and technical aspects of using the robot. The second role is to facilitate the application of technical robotic skills to a specific procedure. RAS is a rapidly evolving field, as evident through the range of simulators and available simulation exercises available. Therefore, it is important to focus on the skills required, rather than the specific mode of delivery, as the latter will continue to evolve and expand.

Virtual reality (VR) is a useful and scalable tool to deliver initial training in basic RAS skills. Basic skills simulation can be completed as individual learning on a hospital- or simulation centre-based VR simulator or delivered as part of basic skills courses from third-party education providers. Individual independent simulator practice and courses also have a role in preparing surgeons for robotic surgery. Similarly, VR and simulation may have a place in the delivery of advanced procedural training, however, there are more potential advantages for these procedural steps when using a high-fidelity laboratory model.

Historically, simulation training has been categorised as follows:

1. Computer-based simulation
2. Dry lab – A basic surgical simulation; these labs have equipped platforms for practising techniques in a realistic setting, however, do not use biological tissues (living or dead)[40]
3. Wet lab – An advanced surgical simulated environment which closely replicates the operative environment as much as functionally possible through use of biological tissues or high-fidelity synthetic models.

The ethical and financial considerations of using cadavers and live animals in training are well known. Whilst basic robotic laboratory model exercises and procedure-specific exercises using animal tissue or synthetic inanimate models may not reliably simulate a true operating environment, they do allow surgeons to develop familiarity and dexterity in performing RAS manoeuvres.

The use of simulation in RAS presents an opportunity to re-define the stages required for appropriate credentialing, as technological advances are likely to significantly decrease reliance upon such models in future. It is suggested that moving forward, the simulation training pathway is recategorised as:

- **Stage 1 Virtual reality simulation**; incorporating all computer-based and virtual reality simulation exercises
- **Stage 2 Basic exercise-based simulation**; basic and complex surgical simulation skills
- **Stage 3 High-fidelity laboratory**; advanced surgical simulated environment which closely replicates the operative environment as much as functionally possible through use of high-fidelity models including cadaveric, animal and/or synthetic materials.

3.11.3. Industry courses

All of the major robotic vendors operating in Australia and Aotearoa New Zealand provide training programs, most with an online training component; to date, this type of training has formed the basis for initial robotic accreditation. Industry courses provide surgeons with opportunities to familiarise themselves with the specifics, nuances and functions of each platform, establishing/promoting transference of basic, universal RAS skill set across the various RAS models. This provides a solid foundational skill set that can be more broadly applied across a range of robotic devices.

With an anticipated expansion of RAS platforms in hospitals, it is feasible that hospitals will install robotic platforms from one, or a number of, vendors. As it will be necessary for surgeons to work across multiple platforms, it is essential they also have access to platform-specific training, to contextualise their skills to each platform. It is unlikely that the industry-led aspects of platform training will be omitted from the RAS training pathway, as this is common practice in industry where vendor representatives assist with familiarity and use of products.

3.11.4. Health facility based courses

RAS courses are also being developed and delivered within various facilities that are not industry funded and have research backing. In one institution, a paediatric robotic mini-Fellowship program was developed and delivered over five days. The program relies heavily on expert faculty to instruct and proctor and requires a completely outfitted robotic laboratory with access to both basic and high-fidelity exercise-based simulation[41].

Similarly, hospitals are providing immersive RAS training programs conducted full time over one or multiple years. These training programs include all elements of the previously discussed training pathways, with the advantage of a far more extensive proctoring component.

3.12. Training implications for regional, rural and remote Trainees and surgeons

The current robot-assisted surgery landscape means that many of the robots available in Australia and Aotearoa New Zealand have been installed in metropolitan locations within the private sector. Access to training is another major limiting factor, with considerable access inequity for surgical patients, as well as Trainees and Fellows seeking RAS training and exposure. Rural patients face more challenges in access when compared to metropolitan based patients, which also impacts. This is a consideration in broadening access to training opportunities.

The drain of robotic cases to metropolitan centres will have implications for Registrar training in rural and remote regions, and further exacerbate the health divide between metropolitan and regional, rural and remote locations. The introduction of robotic platforms in major regional, rural and remote centres is important to attract and maintain skilled surgeons, as well as offer greater opportunities to Trainees; this has been observed in recent installations at Ballarat, Geelong and Newcastle hospitals.

The challenges to widespread training include considerable infrastructure costs and limited access to experts. Remote mentoring and video platforms can reduce costs and overcome geographic limitations, facilitating remote surgical education and the transfer of knowledge between surgeons in an educational setting. The future of robotic surgery training looks promising, with advancements in emerging technologies offering real-time feedback and immersive training environments, leading to greater technical competence and improved patient outcomes[2].

4. CREDENTIALING AND PRACTICE

Surgical robotic platforms can be considered an extension of the tools at the disposal of a surgeon, similar to laparoscopy or the use of other technology such as energy devices. However, akin to laparoscopy, there is a significant learning curve associated with the use of robotic platforms. Therefore, it is imperative surgeons using this technology are familiar with both the platform and the associated procedures, with good understanding of the specific nuances of performing the procedures robotically.

As discussed earlier in this report, RAS training requires purposeful actions to develop competence with the robotic platforms as well as deliberate experience, for example in the form of formal Fellowship training, to learn specific robotic procedures. It is acknowledged that currently individual robotic platforms are supported by vendor-led courses and both simulators and laboratories are considered helpful in familiarising practitioners with both the technology and individual procedures. Simulation has already come to be regarded as an essential component of RAS training.

Surgeons would be expected to perform robotic procedures within their discipline and existing scope of practice. Protection of the public, along with assurance that surgeons are appropriately trained and credentialed must be a consideration. With the evolution of RAS technology, technique and training that surgeons require to convert to open for some procedures has become a rarity. In an ideal situation, surgeons would be able to convert a surgery to an open procedure to complete a case, however it is becoming increasingly apparent that more recently qualified surgeons will have minimal or no experience with the open surgery approach. In such situations, it would be advantageous to have a colleague on standby to assist, as required.

To ensure safe surgical practice and the safety of consumers, National Safety and Quality Health Service (NSQHS) Standard 1: Governance for Safety and Quality in Health Service Organisations[42] requires health service organisations to implement a system that determines and regularly reviews the roles, responsibilities, accountabilities and scope of clinical practice for the clinical workforce. Currently, the specific credentialing policies for the introduction of new technologies, RAS included, is the responsibility of individual health service organisations.

A recent review of a representative sample of 42 hospital-credentialing policies in the USA identified significant variability in robotic surgery credentialing policies [43]. It is highly likely that there may also be a similar lack of standardisation in the credentialing process in Australia and Aotearoa New Zealand, raising safety concerns for both consumers and healthcare providers engaged in the use of robotic surgery. Industry vendors further promulgate the sense of urgency around credentialing, given their desire for increased adoption of RAS and use of associated consumables.

Individual credentialing pathways may vary within an institution but ultimately should include:

- Credentialing requirements based on pathway
- Maintenance of privileges requirements
- Other requirements

When considering credentialing, it is important to focus on controllable items (for example, maintenance of a logbook, relationship with proctor, simulator time to maintain skills in the absence of cases) and be less prescriptive on factors that are less controllable (for example, minimum number of cases, maximum gap allowed between cases).

Individual credentialing pathways may vary within an institution, but ultimately take into account the individual surgeon's experience and training; their existing scope of practice; privileges requested; and experience with the robotic platform. Ongoing practice is contingent upon demonstration of safe outcomes, recency of practice, satisfactory case volumes as appropriate to the specialty, participation in ongoing audit and commitment to improvement. The emphasis should be on recency of practice, rather than case volumes, given the variability in access across the industry which may make it an unfair indicator of credentialing. Consideration must also be given to specialties where conditions and procedures are less common.

4.1. In what environment is it appropriate to perform robot-assisted surgery?

Current experience in RAS mirrors that of the introduction of laparoscopic surgery in Australia and Aotearoa New Zealand in the 1990s and early 2000s. RAS platforms have been installed and used effectively in public and private hospitals in rural and metropolitan locations. This has occurred largely without event. Facility size has not impacted installations, as RAS platforms have been effectively rolled out in small, medium and large hospitals, and used in theatres of varying sizes. The portability of the RAS platforms and consoles do not necessitate additional environmental adjustments to theatres to accommodate it.

Whilst RAS has been predominantly rolled out in private sector, and non-teaching environments, it has been successfully introduced in training environments with and without a second or dual console installed.

4.2. What criteria does a surgeon need to fulfil to be appropriately credentialed in robot-assisted surgery?

Currently, there are two pathways to achieve appropriate credentialing in RAS: either completion of surgical Fellowship which includes formal robotic training or non-Fellowship training which includes various combinations of didactic, simulation, lab-based and live-theatre training. Ultimately the credentialing process that applies to RAS remains at a local level, with responsibility lying with the individual institution's credentialing committee [44].

In the absence of professional organisation-led recommendations, the majority of hospitals in Australia and Aotearoa New Zealand have opted to implement a hybrid of industry recommendations and experience of other institutions.

The key elements of credentialing requirements are based upon the completion of online modules, virtual reality simulation, basic exercise-based simulation, high-fidelity laboratory, observation and proctored cases[45]. Institutional requirements may vary for the required number of proctored cases; however, the minimum number appears to be three proctored cases, which generally leads to conditional credentialing, following a defined number of cases, typically in the vicinity of 20. Following initial credentialing, maintenance of credentialing is generally based upon the number of cases performed over a proceeding period of time, which may range from a minimum of 10 to 20 cases[46,47].

We support the use of online learning materials, simulation and a defined basic exercise-based simulation (basic familiarisation with the product), with high-fidelity laboratory, which may include use of synthetic organ models, and proctored case volume in order to achieve credentialing requirements. It is imperative the proctored cases demonstrate the procedure the surgeon intends to perform regularly.

Rather than specifying credentialing criteria, surgeons should focus on meeting criteria based upon competency rather than achieving case number targets. For example, instead of ticking off requirements for completing simulation activities, surgeons should aspire to achieve metrics for success/error rates, as well as components such as time-based proficiency and efficiency of movement.

Achievement of metrics is particularly important for surgeons who experience issues with access to robots, as maintenance of skills can be achieved through the use of simulators.

A recent study of skills acquisition using the da Vinci skills simulator demonstrated rapid acquisition of basic robotic surgical skills within the ten repetitions, however, this was insufficient for most novices to achieve an expert skill level[48]. The study identified steady improvement for the following parameters, which should be considered for criterion-based training and credentialing measures to an expert level: time to complete; instrument collisions; critical errors; and economy of motion[48].

4.2.1. Proposed credentialing requirements for robot-assisted surgery

The process for accredited surgeons to train and attain accreditation in robotic surgery leads to:

- Step 1: Proctor-Supervised Surgeon
- Step 2: Provisionally Accredited Surgeon
- Step 3: Fully Accredited Surgeon
- Step 4: Accredited Proctor Surgeon

A RAS governance committee should be established at each institution to provide oversight to the credentialing process, and for which the Terms of Reference will be determined according to the local requirements.

4.2.1.1. Step 1: Proctor-Supervised Surgeon

1. Introduction to console
   - Completion of the online training modules and associated assessments
   - Participation in console familiarisation activities with an appropriate representative
   - Completion of a minimum of > 90 per cent accuracy on allocated Stage 1 Virtual reality simulation modules
   - Observation of a minimum of five robotic cases on the console, all of which must be in the surgeon’s specialty area
   - Observation of procedural videos
   - Completion of a minimum of four hours Stage 2 Basic exercise-based simulation on the console

Note: Observed cases must include observation of patient positioning, bedside assistance, port placement, docking and undocking.

Note: Observed procedural videos must be consistent with the intended scope of surgical practice for RAS.

Note: It is the surgeon's responsibility to ensure they have observed and understood a sufficient number of videos detailing surgical components. The surgeon must be satisfied they have confidence with and understanding of each of the required procedural steps for all procedures within the intended scope of surgical practice for RAS.

Note: It is imperative that surgeons do not proceed to Stage 3 High-fidelity laboratory training until competency has been achieved for Stage 2 Basic exercise-based simulation tasks. For example, surgeons must be comfortable and proficient with stitching and knot tying.

2. Stage 3 High-fidelity laboratory
   - Attendance at Stage 3 High-fidelity laboratory training at a certified course for the console

Note: Although high-fidelity laboratory implies the use of biological tissue, including animals and cadavers, however we also endorse the use of synthetic models. If a feasible and equivalent alternative to non-human animal tissue exists its use is encouraged wherever possible.

Note: There will be circumstances where local consultant-led training pathways may not require Stage 3 High-fidelity laboratory training as a prerequisite to direct consultant-supervised component operating upon completion of online learning and Stage 2 Basic exercise-based simulation. However, it is strongly recommended that surgeons are given opportunities for Stage 3 High-fidelity laboratory training to accelerate their learning curve.

Note: Competency for high-fidelity laboratory tasks must be supervised and should only be assessed by an appropriately trained assessor/proctor.

3. Proctor supervision

    - An appointment letter will be issued confirming scope of practice and an appropriately qualified accredited proctor assigned. The first proctored case should be performed following successful completion of Stage 3 High-fidelity laboratory, and within 6-12 months of completing the Stage 3 High-fidelity laboratory training program.
    - Completion of proctor supervision requires a Certification Letter of Completion by proctor which confirms completion of a minimum of five proctored cases have been completed in which the accredited surgeon demonstrated both competency and safety when using the robot. The first proctored case should be performed within 6-12 months of completing the Stage 3 High-fidelity laboratory training.

Note: At the completion of the five proctored cases, the proctor must certify that the accredited surgeon has attained at least a minimum level of competency and safety with the equipment or that additional proctoring is required until expected proficiency is demonstrated. It has been shown that it is possible to safely achieve acceptable short-term outcomes with appropriate training[49].

Note: The five proctored cases must be consistent with the intended scope of surgical practice for RAS.

Note: If the proctor is from an external institution, their temporary privileges must include authorisation to take over in the event the surgeon being proctored encounters difficulties.

4.2.1.2. Step 2: Provisionally Accredited Surgeon

Provisional Accreditation allows an accredited surgeon to complete 10 cases as a solo practitioner. This level of accreditation can be obtained in one of two ways:

- For surgeons training in robotic surgery; successful completion of the requirements for Proctor-Supervised Surgeon, as well as approval from local RAS governance, or
- For experienced robotic surgeons, including those who have completed a robotic surgery Fellowship, the local RSAS governance accepts evidence that requirements have been met. As a guide, the requirements are:
    - Certificated evidence of completion of a recognised robotic surgery training program; and,
    - A case log of at least 20 completed cases performed independently.

Note: It is reasonable that some institutions will proceed directly to Full Accreditation for a surgeon on a case-by-case basis.

1. Audit of first 10 solo cases

    - The performance of the Provisional Accredited Robotic Surgeon will be continuously monitored and provided there are no emergent issues, a full audit of the first 10 solo cases will be conducted by local RAS governance and suitably qualified senior member(s) of clinical staff. It is the responsibility of the Provisional Accredited Robotic Surgeon to compile the documentation for the audit of their first 10 solo cases, which should include at a minimum: operative times, complications and length of stay.

2. Oversight governance decision
    - Following completion of this audit, local RAS governance will make one of the following recommendations:
        - Approve at the full accredited level
        - Continued provisional accreditation and review after a further 10 cases;
        - Further proctoring as set out under proctor supervision process; or
        - Cease performing robotic surgery at the institution.

All decisions should be communicated to the surgeon in writing.

4.2.1.3. Step 3: Fully Accredited Surgeon

A Fully Accredited Robotic Surgeon has satisfactorily met the above requirements, with CEO approval given confirming the advanced scope of practice on the recommendation of the committee.

To maintain Fully Accredited status, an accredited surgeon must comply with the following requirements:

- Demonstrate they have an ongoing case load (Note: This will be determined by the local credentialing committees based upon specialty and type of surgery. Case load may be achieved across multiple hospitals). If the ongoing case load requirement has not been met, then the surgeon must produce an audit of all their cases including details of operative times, complications and length of stay.
- Contribute to, and comply with, the morbidity and mortality (M&M) participation requirements of the institution.

4.2.1.4. Step 4: Accredited Proctor Surgeon

There are two types of proctor accreditations:

- The proctor is also a Fully Accredited Surgeon; or
- Proctor Only Accreditation with no other privileges (e.g., admitting privileges) at the institution, including full, long-term accreditation of up to 5 years, or short term temporary appointments.

Requirements for Fully Accredited Surgeons seeking proctor accreditation:

- The Fully Accredited Surgeon must submit their request for an extended scope of practice with a case log which demonstrates a minimum of 50 robotic procedures were completed in the preceding two-year period. The case log must specify at a minimum: operative time, complications and length of stay.

Requirements for Proctor Only Accreditation:

- For full, long-term accreditation of up to five years the applicant must provide the following:
    - Submit an application with required supporting documents;
    - Proof of independent RAS performance, including a minimum of 50 robotic procedures completed in the preceding two-year period;
    - Certificate of Completion for vendor-provided training, and/or confirmation of completion of a Robotic Surgery Fellowship.

- For a temporary six-month appointment, the applicant must provide the following:
    - Basic contact information, AHPRA number, current CV, a copy of their current indemnity insurance policy, mandatory vaccine evidence and two nominated referees including at least one current head of department;
    - Proof of independent RAS performance, including a minimum of 50 robotic procedures completed in the preceding two-year period;
    - Proof of an equivalent, existing full accreditation at their own institution;
    - Certificate of Completion for vendor-provided training, and/or confirmation of completion of a Robotic Surgery Fellowship.

4.2.1.5. The Proctor Role

- The proctor role is primarily one of supervision, training, guidance and evaluation; however, if the surgeon being proctored encounters difficulties, then the proctor is authorised and expected to take over and complete the case if necessary.
- If local resources are unavailable once minimum standards have been met in face-to-face learning, further ongoing support may be provided during the transition to independent RAS practice by remote tele-mentoring, as required.
- The proctor must remain in the operating theatre at all times for an accredited surgeon's first five cases on the robotic console and in situations where additional proctor supervision is required.
- After each proctored case, the proctor is required to complete an evaluation form (See **Appendix 3: Robotic Surgery Evaluation Form**)

Currently, proctoring outcomes are reported using a simple evaluation form (see **Appendix 3: Robotic Surgery Evaluation Form**), which is appropriate to capture a minimum standard. In the future, it may be beneficial to integrate measurement of clinically relevant performance metrics to objectively assess proficiency in both simulation and cases, which may assist RAS surgeons in further improving their technical performance [50]. The Global Evaluation and Assessment of Robotic Surgery (GEARS) score has been demonstrated to have construct validity in differentiating between expert, intermediate and novice learners[51]. Procedure-based proficiency scores are being developed, which may be a useful adjunct to learning[52], along with GEARS scores which can be useful as a formative tool.

4.3. What quality assurance and CPD activities should a surgeon participate in?

Quality assurance and CPD activities for RAS should align with the Medical Board of Australia (MBA) CPD registration standard and recertification requirements set by the Medical Council of New Zealand (MCNZ). The areas of practice should be developed in consultation with specialty associations and societies, with ongoing feedback provided to ensure that they remain relevant and contemporary. The RACS CPD Home Program is based on a continuous cycle of learning with a focus on planning, participation, measuring outcomes, reflection and change and includes standard annual activities with minimum requirements[53].

There are no anticipated specific or additional CPD requirements as part of RACS CPD Home offering to cover the RAS modality; it can be included in activities for the technical expertise and medical expertise competencies.

4.4. What are key indicators that surgical practice is to an appropriate standard?

It is outside the scope of RACS to determine key indicators of a specific procedure. The specialty training boards are responsible for standard setting activities for their respective specialty curriculum. This extends beyond curriculum and the SET training program and includes the key indicators for procedure- and specialty-specific surgical practice.

It is expected that that peer review process would assist with maintaining standards of surgical practice, including audit and reflection of case numbers and proctoring. A reasonable standard of surgical practice should also incorporate comparison of outcomes with accepted levels.

4.5. What information about robot-assisted surgery must patients be informed about?

As established in Rogers v Whitaker[54], a doctor has a duty to warn a patient of any material risk involved in a proposed treatment. This applies to RAS as patients must be informed of the nature and material risks of the surgery, and patients are able to make judgements about the significance of surgical risks. Alternative standardised procedures, if available, should always be discussed and offered to patients.

Information regarding the credentialing or number of RAS procedures the surgeon has undertaken are not published or made publicly available. The growth and use of numerical metrics related to initial and ongoing accreditation will create challenges in the disclosure of patient experience, consequently, patients are likely to request this information from surgeons in future.

4.6. What steps are needed to ensure equity of patient access across our communities?

The distribution of robotic platforms in Australia and Aotearoa New Zealand significantly favours metropolitan centres and private hospitals. It is important to address equity of care and access across public and private hospitals, as installation of robots has started in public hospitals and is expected to increase significantly in the coming years.

Equitable rollout of robotic platforms in metropolitan, rural and low socio-economic communities is essential, with Government funding to support it. The introduction of robotic platforms in major regional, rural and remote centres is vital to attract and maintain skilled surgeons; this has been evident in recent installations at Ballarat, Geelong and Newcastle hospitals. With robotic technology currently available in very few public hospitals, all patients within the hospital referral networks will benefit from the availability of the new robotic technology[55].

Surgeons returning from Fellowship will seek work placements with access to robotic platforms. If rural hospitals do not have these facilities, they risk losing access to a generation of skilled specialists. A significant delay in rollout to rural hospitals could ultimately lead to a generation of surgeons with a robotic skill set who are unwilling to accept rural placements. Communities benefit most from surgeons who have opportunities to learn skills during early training and throughout their careers. Mid-career surgeons may need to learn robotic skills in order to effectively serve the community.

The superior surgical outcomes achieved by RAS to date may encourage the pilot and implementation of government-subsidised programs nationally, to help facilitate rural patient access to these services. This could be justified by economic and Quality Adjusted Life Year (QALY) measures for example, that demonstrate better patient outcomes. Using radical prostatectomy as an example, a recent study concluded that RAS is cost-effective compared to laparoscopic surgery when evaluating long-term health and economic effects at most acceptable willingness to pay (WTP) ratios[56]. In this case, RAS also showed higher QALYs when compared to laparoscopic surgery. When robot-assisted radical prostatectomy is centralised and surgeons are experienced with robotic platforms and/or the robotic platforms are used in multiple indications, RAS becomes cost-effective at all WTP ratios and has the potential to be cost-saving[56].

4.7. Credentialing implications for regional, rural and remote Trainees and surgeons

The skewed distribution of surgical robots strongly in favour of metropolitan hospitals means attaining robotic accreditation and robotic access is challenging for regional, rural and remote surgeons. Currently, in regional, rural and remote centres RAS is generally restricted to private patients, however public robotic access is even more elusive, and generally distributed in metropolitan locations. In some cases, regional, rural and remote surgeons are investing significant amounts of time and associated costs to travel to metropolitan centres to achieve accreditation and perform procedures on their patients before it is deemed financially feasible for their local hospital to invest in a robotic platform. It is estimated that access to a robotic platform in a public hospital in a regional, rural or remote centre could easily increase Trainee caseload at an estimate of two- to three-fold. Recent platform installations at public hospitals in Ballarat, Geelong and Newcastle are expected to offer greater opportunities to Trainees and contribute to attracting and maintaining skilled surgeons to their respective areas.

A solution to the issue could be the establishment of formal links between rural surgeons and metropolitan hospitals with robotic access. This would enable rural surgeons to be trained in a safe, supportive environment in an established robotic centre. Ideally, once the rural surgeon is robotically proficient, a robotic platform could then be secured at their regional, rural or remote hospital.

This is a safe way for the robotic technology to be introduced in new settings, as the surgeon's established links with their metropolitan proctors, as well as nursing staff, can provide additional support as required.

Some surgeons are already implementing this model, where they are in regular contact with proctors regarding complex cases. If the surgeon deems a case too complicated to be done regionally (e.g., if another subspecialty may be required) the case is then performed in a metropolitan hospital. Not all metropolitan private hospitals are supportive in providing accreditation for robotic privileges for rural surgeons, who in some situations have been restricted to assisting only or have no robotic access. In instances where a rural surgeon feels the patient would benefit from the procedure being conducted by RAS, they refer their patients to metropolitan centres rather than performing the operation locally. While hospitals utilise telehealth consultations with robotic colleagues in metropolitan hospitals, post-operative care is provided by rural surgeons. Although this system works, the ideal would be for regional, rural and remote patients to have local access to RAS, improving equity of access to RAS and improved outcomes.

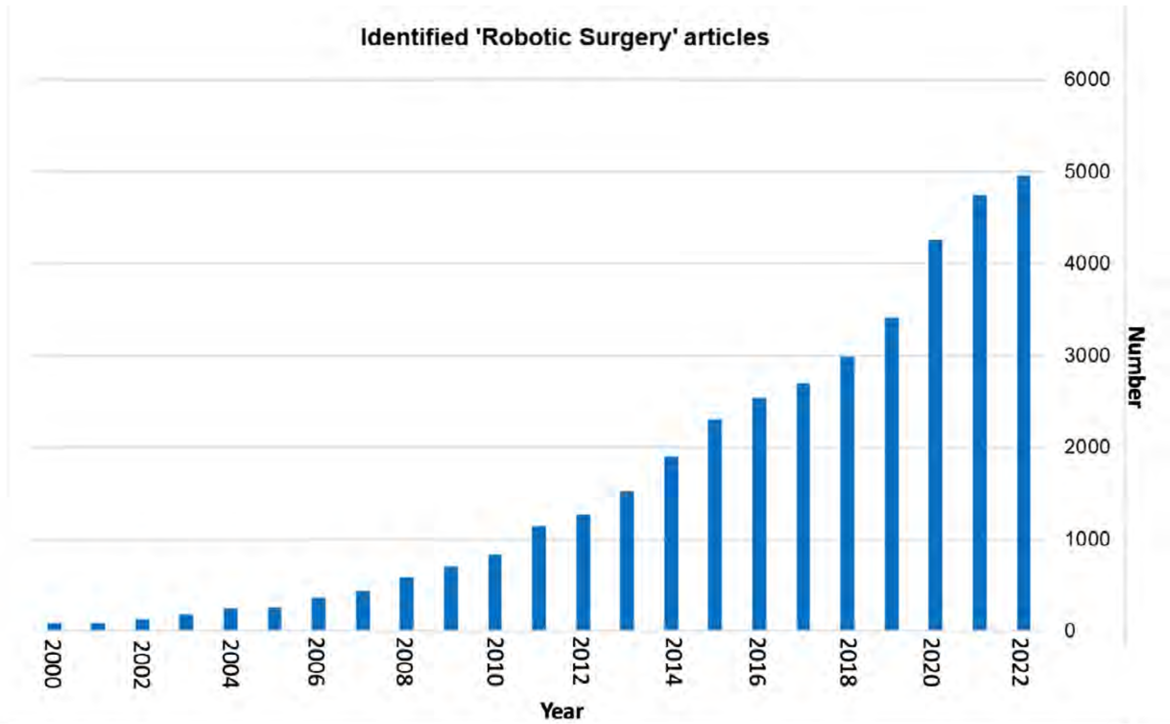
Regional, rural and remote Trainees will reach robotic independence much faster if they are provided equitable access to public patients during training and mentorship due to a larger case volume. Regional, rural and remote patients deserve the same level of care as is available in metropolitan centres.

5. RESEARCH

5.1. What research should be undertaken to inform education, training and practice?

The volume and scale of research in RAS has expanded exponentially from 2000 to 2023. A simple search on PubMed with the term ‘Robotic Surgery’ demonstrates an increase in identified articles from 84 in 2000 to 4,965 in 2022.

Figure 4. Identified Robotic Surgery articles



Whilst research does exist on determinants of competency, it is insufficient to reliably base direct application of these findings. Some of the questions with respect to competency-based training that should be undergo further research include:

- Confirming components of training pathways that are directly linked to competency at various stages of training.
- What defines competency at each level of training that would allow progression to the next stage of training? This applies to both simulation and proctored surgeon stages of training.
- What is the impact of prior learning in both laparoscopic and open surgery on the acquisition of skills for a given procedure
- What is the impact of video review of full length or component modules of an operation in achieving competency or maintenance of skills competency.
- What is the impact of prior learning in both laparoscopic and open surgery experience on the acquisition on competency in RAS?
- Is there a role for tele-mentoring?
- What defines a proctor surgery and the ability to perform this role?
- How should competencies for newly credentialled RAS surgeons be defined for maintenance of credentialling?
- Can simulation be used to maintain RAS skills?
- Is lack of access to RAS exacerbating recruitment and retainment of surgeons to hospitals that do not have such technology?
- Will a lack of access to RAS impact upon the competitiveness of SET graduates who apply for post FRACS Fellowships in institutions that may seek candidates with prior experience?

In the case of clinical research into the outcomes including safety and efficacy of RAS, the working group believes research for robot-assisted surgery should be separated into two areas:

- Audit at the individual and institutional levels, and beyond
- Evaluating the nuances of a new approach (similar to the body of evidence in laparoscopic surgery, new techniques in open surgery). Thus, the clinical questions are likely to be broadly similar and will be initiated by clinicians with increasing use

Safety and effectiveness are logical areas for research as it will encourage and inform best practice, and the data captured by vendors will contribute to this. As retrospective research data is already available, prospective research is required in RAS, and would be obtained through ethics approval processes. Prospective research may include;

- Measurement of Patient Reported Outcome Measures (PROMS), Patient Reported Experience Measures (PREMS) and quality of life metrics, which are measured poorly in current practice, and would contribute to changing practice
- Evidence that RAS leads to increased outcomes for the community, including patient recovery time and return to normal activities
- Evidence that RAS has the potential to learn bulk skills through the use of simulation, and consequently shortens the required learning curve when operating.
- Mechanisms to allow benchmarking of RAS outcomes.

6. RECOMMENDATIONS

Evidence suggests that the existing robot-assisted surgery curriculum approaches appear to be effective, although require further refinement. In the interim, it is reasonable to support continued use of these pathways. Cost and limited resources were identified as a challenge in training for RAS. A hybrid funding model for robot-assisted surgery training may be an effective and pragmatic approach. An opportunity may present itself for volume discounts or industry subsidising from alternative funding sources. It was also identified that there is a need for development of, and research into, competency-based criteria for credentialing. Surgeons should aspire to meet criteria based upon competency rather than completion of case numbers. Recommendations that have arisen from the working party are outlined below.

6.1. RACS specialty training boards to consider introducing robot-assisted surgery training into respective SET curriculum. At this point in time, this may primarily be limited to simulation experience. Equal opportunities must be provided for metropolitan and regional, rural and remote Trainees. (See section 3.8, page 11)

6.2. RACS specialty training boards to set the standards of robot-assisted surgery education and training, and graduate outcomes for their respective specialty curriculum. RACS, through the Committee of Surgical Education and Training (CSET) and Education Committee, can provide guidance for general and overarching robot-assisted surgery curriculum and required educational content, however specialty-specific guidance should be provided by the respective specialty training boards and sub-specialty organisations. (See section 3.6, page 11)

6.3. Recommend a staged simulation training pathway. We have defined the simulation training pathway as:

- Stage 1 Virtual reality simulation; incorporating all computer-based and virtual reality simulation exercises
- Stage 2 Basic exercise-based simulation; basic surgical simulation which does not use biological tissues (living or dead)
- Stage 3 High-fidelity laboratory; advanced surgical simulated environment which closely replicates the operative environment as much as functionally possible through use of high-fidelity models including cadaveric, animal and/or synthetic materials (See section 3.11.2, page 13)

6.4. Endorsement of a credentialing pathway for robot-assisted surgery. The process for accredited surgeons to train and attain accreditation in robotic surgery would lead to:

- Proctor-Supervised Surgeon
- Provisionally Accredited Surgeon
- Fully Accredited Surgeon
- Accredited Proctor Surgeon (See section 4.2.1, page 17)

6.5. Recommend establishment of a RAS governance committee at each institution. This will provide oversight to the credentialing process, and for which the Terms of Reference would be determined according to the local requirements. (See section 4.2.1, page 17)

Professor Henry Woo
Chair, Robot-Assisted Surgery Working Party

APPENDIX 1
ROBOT-ASSISTED SURGERY WORKING PARTY TERMS OF REFERENCE

Division:	**Education**	**Ref. No.**	**TOR**
Department:	**Education Research and Innovation**		
Title:	**RACS Robot-Assisted Surgery Working Party**		

1. PURPOSE AND SCOPE

These terms of reference establish the RACS Robot-assisted Surgery Working Party

2. KEYWORDS

Robot-assisted Surgery, education and training, safety and efficacy, credentialing, research.

3. BODY OF POLICY

3.1. Background

Robot-assisted surgery is growing in prominence, with significant increases in the number of procedures undertaken using this modality. The extent to which robot-assisted surgery is performed differs between specialties, with particular procedures already offered across Urology, Otolaryngology Head and Neck Surgery, Neurosurgery, Orthopaedic Surgery and General Surgery.

Given the reasonable prevalence of robot-assisted surgery, it is timely to consider the position of RACS, and partners, in this evolving space. Determining the responsibility of RACS in defining standards of robot-assisted surgery education and training, standards of practice, and advocacy in resource equity is key, given RACS' responsibility to ensure appropriate self-regulation of surgical practice. There are a number of considerations that shape these decisions.

3.2. Duties and responsibilities

To review available evidence, information and experiences in order to advise Council on the following issues;

3.2.1. Safety and efficacy

- What is the safety and efficacy data to support the role of robot-assisted surgery?
- Is robot-assisted surgery a cost-effective modality of operative intervention?
- What data should be systematically collected to monitor and evaluate safety, efficacy and cost-effectiveness?

3.2.2. Surgical education and training

- What would best-practice education and training in robot-assisted surgery look like?
- Who should deliver and govern training in robot-assisted surgery?
- Who would qualify to instruct / train in robot-assisted surgery?
- Who should determine the educational content?
- Who should set the standards of education and training?
- What are the graduate outcomes of training in robot-assisted surgery?
- Should training commence before, during and, or after SET?
- How should education and training be resourced, funded and accessed?

3.2.3. Credentialling and practice

- In what environment is it appropriate to perform robot-assisted surgery?
- What criteria does a surgeon need to fulfill to be appropriately credentialed in robot-assisted surgery.
- What quality assurance and CPD activities should a surgeon participate in?
- What are key indicators that surgical practice is to an appropriate standard?

- What information about robot-assisted surgery must patients be informed about?
- What steps are needed to ensure equity of patient access across our communities?

3.2.4. Research

- What research should be undertaken to inform education, training and practice around robot-assisted surgery?

3.3. Composition and appointment

3.3.1. The Working Part will comprise of the following:

- Chair (RACS Councillor)
- Surgical Specialty representatives
- Trainee representative
- Skills Education representative
- Royal Australian and New Zealand College of Obstetricians and Gynaecologists representatives
- Medical Technology Association of Australia representative
- Rural representative
- Community representative
- Education staff representatives
- Medical Educator

3.3.2. The Chair of the Working Party is appointed by the Education Board

3.4. Meetings

The Working Party shall hold monthly meetings and such other meetings as it deems necessary.

3.5. Accountability and reporting structure

The RACS Robot-assisted Surgery Working Party will be convened in June 2022. The Working Party will provide a final report and recommendations to the Education Board by June 2023.

APPENDIX 2
RANDOMISED CONTROL TRIALS (RCT)

TRIAL DETAILS	TRIAL OBJECTIVE	TRIAL OUTCOME
Anger JT, Mueller ER, Tarnay C, Smith B, Stroupe K, Rosenman A, Brubaker L, Bresee C, Kenton K. Robotic compared with laparoscopic sacrocolpopexy: a randomised controlled trial. Obstet Gynecol. 2014 Jan;123(1):5-12. doi: 10.1097/AOG.0000000000000006. Erratum in: Obstet Gynecol. 2014 Jul;124(1):165. PMID: 24463657; PMCID: PMC4266590.	Laparoscopic and robotic sacrocolpopexy are widely used for pelvic organ prolapse (POP) treatment. Evidence comparing outcomes and costs is lacking. We compared costs and clinically relevant outcomes in women randomised to laparoscopic sacrocolpopexy compared with robotic sacrocolpopexy.	Costs of robotic sacrocolpopexy are higher than laparoscopic, whereas short-term outcomes and complications are similar. Primary cost differences resulted from robot maintenance and purchase costs.
Bishop SN, Asaad M, Liu J, Chu CK, Clemens MW, Kapur SS, Largo RD, Selber JC. Robotic Harvest of the Deep Inferior Epigastric Perforator Flap for Breast Reconstruction: A Case Series. Plast Reconstr Surg. 2022 May 1;149(5):1073-1077. doi: 10.1097/PRS.0000000000008988. Epub 2022 Mar 7. PMID: 35255056.	Robotic surgery is emerging as a viable tool in reconstructive surgery. Harvesting of the deep inferior epigastric perforator flap is typically performed through an anterior approach, which involves a long fascial incision. A robotic approach allows the deep inferior epigastric pedicle to be harvested from the posterior surface. This approach reduces the length of the fascial incision and should decrease the abdominal morbidity associated with large fascial dissections.	The robotic deep inferior epigastric perforator flap is a safe and reliable technique that decreases the length of fascial incision and short-term complications associated with the open approach.
Cleary RK, Silviera M, Reidy TJ, McCormick J, Johnson CS, Sylla P, Cannon J, Lujan H, Kassir A, Landmann R, Gaertner W, Lee E, Bastawrous A, Bardakcioglu O, Pandey S, Attaluri V, Bernstein M, Obias V, Franklin ME Jr, Pigazzi A. Intracorporeal and extracorporeal anastomosis for robotic-assisted and laparoscopic right colectomy: short-term outcomes of a multi-center prospective trial. Surg Endosc. 2022 Jun;36(6):4349-4358. doi: 10.1007/s00464-021-08780-9. Epub 2021 Nov 1. PMID: 34724580; PMCID: PMC9085698.	The purpose of this study was to compare intracorporeal and extracorporeal anastomoses outcomes for robotic assisted and laparoscopic right colectomy.	In this prospective, multi-center study of minimally invasive right colectomy across 20 institutions, intracorporeal anastomosis (IA) was associated with significant improvements in conversion rates, return of bowel function, and shorter hospital stay, as well as significantly longer operative times compared to EA. These data validate current efforts to increase training and adoption of the IA technique for minimally invasive right colectomy.
de Groot EM, van der Horst S, Kingma BF, Goense L, van der Sluis PC, Ruurda JP, van Hillegersberg R. Robot-assisted minimally invasive thoracolaparoscopic esophagectomy versus open esophagectomy: long-term follow-up of a randomized clinical trial. Dis Esophagus.	Initial results of the ROBOT, which randomized between robot-assisted minimally invasive esophagectomy (RAMIE) and open transthoracic esophagectomy	No statistically difference in recurrence rate nor recurrence pattern was observed between both groups. Overall survival and disease-free survival of

2020 Nov 26;33(Supplement_2):doaa079. doi: 10.1093/dote/doaa079. PMID: 33241302.	(OTE), showed significantly better short-term postoperative outcomes in favour of RAMIE. However, it is not yet clarified if RAMIE is equivalent to OTE regarding long-term outcomes. The aim of this study was to report the long-term oncological results of the ROBOT trial in terms of survival and disease-free survival.	RAMIE are comparable to OTE. These results continue to support the use of robotic surgery for oesophageal cancer.
Dhanani, Naila H. MD∗; Olavarria, Oscar A. MD, MS∗; Holihan, Julie L. MD, MS∗; Shah, Shinil K. DO∗; Wilson, Todd D. MD∗; Loor, Michele M. MD†; Ko, Tien C. MD∗; Kao, Lillian S. MD, MS∗; Liang, Mike K. MD‡. Robotic Versus Laparoscopic Ventral Hernia Repair: One-year Results From a Prospective, Multicenter, Blinded Randomized Controlled Trial. Annals of Surgery 273(6):p 1076-1080, June 2021. | DOI: 10.1097/SLA.0000000000004795	The aim of this study was to compare clinical and patient-reported outcomes of robotic versus laparoscopic ventral hernia repair (LVHR) at 1-year postoperative.	This study confirms that robotic ventral hernia repair is safe when compared to laparoscopy. Further studies are needed to confirm these findings.
Emile SH, Horesh N, Garoufalia Z, Gefen R, Zhou P, Strassman V, Wexner SD. Robotic and laparoscopic colectomy: propensity score-matched outcomes from a national cancer database. Br J Surg. 2023 Apr 20:znad096. doi: 10.1093/bjs/znad096. Epub ahead of print. PMID: 37075480.	This study was a propensity score matched outcome study rather than a trial.	Robotic surgery was associated with reduced conversion to open.
Feng Q, Yuan W, Li T, Tang B, Jia B, Zhou Y, Zhang W, Zhao R, Zhang C, Cheng L, Zhang X, Liang F, He G, Wei Y, Xu J; REAL Study Group. Robotic versus laparoscopic surgery for middle and low rectal cancer (REAL): short-term outcomes of a multicentre randomised controlled trial. Lancet Gastroenterol Hepatol. 2022 Nov;7(11):991-1004. doi: 10.1016/S2468-1253(22)00248-5. Epub 2022 Sep 8. PMID: 36087608.	This study aimed to compare surgical quality and long-term oncological outcomes of robotic and conventional laparoscopic surgery in patients with middle and low rectal cancer.	Secondary short-term outcomes suggest that for middle and low rectal cancer, robotic surgery resulted in better oncological quality of resection than conventional laparoscopic surgery, with less surgical trauma, and better postoperative recovery.
Flynn J, Larach JT, Kong JCH, Rahme J, Waters PS, Warrier SK, Heriot A. Operative and oncological outcomes after robotic rectal resection compared with laparoscopy: a systematic review and meta-analysis. ANZ J Surg. 2023 Mar;93(3):510-521. doi: 10.1111/ans.18075. Epub 2022 Oct 10. PMID: 36214098.	Most studies comparing robotic and laparoscopic surgery show little difference in clinical outcomes to justify the expense. This study systematically reviewed and pooled evidence from studies comparing robotic and laparoscopic rectal resection.	Pooled results showed significantly longer operating times for robotic surgery but lower conversion and complications rates, shorter lengths of stay in hospital, better rates of complete mesorectal resection and better three-year overall survival. However, the low number of randomised studies makes most data subject to bias.

Flynn J, Larach JT, Kong JCH, Waters PS, McCormick JJ, Warrier SK, Heriot A. Patient-Related Functional Outcomes After Robotic-Assisted Rectal Surgery Compared With a Laparoscopic Approach: A Systematic Review and Meta-analysis. Dis Colon Rectum. 2022 Oct 1;65(10):1191-1204. doi: 10.1097/DCR.0000000000002535. Epub 2022 Jul 15. PMID: 35853177.	This study aimed to compare quality of life and urinary, sexual, and lower GI functions between robotic and laparoscopic rectal surgeries.	The limited available data suggest that robotic rectal cancer resection improves male sexual and urinary functions when compared with laparoscopy, but there is no difference in quality of life or GI function. Future studies should report all facets of functional outcomes using standardised scoring systems.
Grochola LF, Soll C, Zehnder A, Wyss R, Herzog P, Breitenstein S. Robot-assisted versus laparoscopic single-incision cholecystectomy: results of a randomised controlled trial. Surg Endosc. 2019 May;33(5):1482-1490. doi: 10.1007/s00464-018-6430-7. Epub 2018 Sep 14. PMID: 30218263.	Although single-port laparoscopic cholecystectomy (SILC) is safe and effective, inherent surgeons' discomfort has prevented a large-scale adaptation of this technique. Recent advances in robotic technology suggest that da Vinci Single-Site™ cholecystectomy (dVSSC) may overcome this issue by reducing the stress load of the surgeon compared to SILC. However, evidence to objectively assess differences between the two approaches is lacking.	Da Vinci Single-Site™ cholecystectomy provides significant benefits over Single-Port Laparoscopic Cholecystectomy in terms of surgeon's stress load, matches the standards of the laparoscopic single-incision approach with regard to patients' outcomes but increases expenses.
Illiano E, Ditonno P, Giannitsas K, De Rienzo G, Bini V, Costantini E. Robot-assisted Vs Laparoscopic Sacrocolpopexy for High-stage Pelvic Organ Prolapse: A Prospective, Randomized, Single-center Study. Urology. 2019 Dec;134:116-123. doi: 10.1016/j.urology.2019.07.043. Epub 2019 Sep 26. PMID: 31563536.	To compare robot assisted to laparoscopic sacrocolpopexy, in terms of efficacy, in the treatment of high-stage pelvic organ prolapse.	Robot-assisted sacrocolpopexy provides outcomes comparable to those of laparoscopic with 100 per cent anatomic correction of the apical compartment.
Jimenez C, Stanton E, Sung C, Wong AK. Does plastic surgery need a rewiring? A survey and systematic review on robotic-assisted surgery. JPRAS Open. 2022 May 26;33:76-91. doi: 10.1016/j.jpra.2022.05.006. PMID: 35812356; PMCID: PMC9260262.	This is a paucity of data regarding plastic surgeons' opinions on robotic-assisted surgery (RAS). We developed a questionnaire aimed to survey plastic surgeons regarding training in robotics, concerns about widespread implementation, and new research directions.	Evidence from our survey and review supports the growing interest and utility of RAS within the plastic and reconstructive surgery (PRS) and mirrors the established trend in other surgical subspecialties. Cost analyses will prove critical to implementing RAS within PRS. With validated benefits, plastic surgery programs can begin creating dedicated curricula for RAS.
Joseph JR, Smith BW, Liu X, Park P. Current applications of robotics in spine surgery: a systematic review of the literature. Neurosurg Focus. 2017 May;42(5):E2. doi:	Systematic review of published literature - includes analysis of accuracy of pedicle screws and learning curve in	Robotic surgery with pedicle screw guidance is associated with accurate placement of screws. There

10.3171/2017.2.FOCUS16544. PMID: 28463618.	spinal surgery	is an initial learning curve which improves with time. *Some studies within this meta-analysis are industry sponsored
Olavarria O A, Bernardi K, Shah S K, Wilson T D, Wei S, Pedroza C et al. Robotic versus laparoscopic ventral hernia repair: multicenter, blinded randomised controlled trial *BMJ* 2020; 370 :m2457 doi:10.1136/bmj.m2457	To determine whether robotic ventral hernia repair is associated with fewer days in the hospital 90 days after surgery compared with laparoscopic repair.	This study found no evidence of a difference in 90-day postoperative hospital days between robotic and laparoscopic ventral hernia repair. However, robotic repair increased operative duration and healthcare costs.
O'Malley BW Jr, Weinstein GS, Snyder W, Hockstein NG. Transoral robotic surgery (TORS) for base of tongue neoplasms. Laryngoscope. 2006 Aug;116(8):1465-72. doi: 10.1097/01.mlg.0000227184.90514.1a. PMID: 16885755.	To develop a minimally invasive surgical technique for the treatment of base of tongue neoplasms using the optical and technical advantages of robotic surgical instrumentation. Ten experimental procedures including tongue base exposure and dissections were performed on three cadavers and two mongrel dogs. Transoral robotic surgery (TORS) was then performed on three human patients with tongue base cancers in a prospective human trial.	TORS provided excellent three-dimensional visualisation and instrument access that allowed successful surgical resections from cadaver models to human patients. TORS is a novel and minimally invasive approach to tongue neoplasms that has significant advantages over classic open surgery or endoscopic transoral laser surgery.
Paraiso MF, Ridgeway B, Park AJ, Jelovsek JE, Barber MD, Falcone T, Einarsson JI. A randomised trial comparing conventional and robotically assisted total laparoscopic hysterectomy. Am J Obstet Gynecol. 2013 May;208(5):368.e1-7. doi: 10.1016/j.ajog.2013.02.008. Epub 2013 Feb 8. PMID: 23395927.	To compare surgical outcome and quality of life of robot-assisted laparoscopic hysterectomy with conventional laparoscopic hysterectomy.	Although laparoscopic and robotic-assisted hysterectomies are safe approaches to hysterectomy, robotic-assisted hysterectomy requires a significantly longer operative time.
Paraiso MFR, Jelovsek JE, Frick A, Chen CCG, Barber MD. Laparoscopic compared with robotic sacrocolpopexy for vaginal prolapse: a randomised controlled trial. Obstet Gynecol. 2011 Nov;118(5):1005-1013. doi: 10.1097/AOG.0b013e318231537c. PMID: 21979458.	To compare conventional laparoscopic and robotic-assisted laparoscopic sacrocolpopexy for vaginal apex prolapse.	Both groups demonstrated significant improvement in vaginal support and functional outcomes 1 year after surgery with no differences between groups. Robotic-assisted sacrocolpopexy results in longer operating time and increased pain and cost compared with the conventional laparoscopic approach.

Park JS, Kang H, Park SY, Kim HJ, Woo IT, Park IK, Choi GS. Long-term oncologic after robotic versus laparoscopic right colectomy: a prospective randomised study. Surg Endosc. 2019 Sep;33(9):2975-2981. doi: 10.1007/s00464-018-6563-8. Epub 2018 Nov 19. PMID: 30456502.	The aim of this study was to compare the long-term outcomes of robot-assisted right colectomy (RAC) with those for conventional laparoscopy-assisted right surgery (LAC) for treating right-sided colon cancer.	RAC appears to have similar long-term survival as compared with LAC. However, we did not observe any clinical benefits of RAC which could translate to a decrease in expenditures.
Park JS, Lee SM, Choi GS, Park SY, Kim HJ, Song SH, Min BS, Kim NK, Kim SH. Comparison of Laparoscopic versus Robot-Assisted Surgery for Rectal Cancers: The COLRAR Randomised Controlled Trial. Ann Surg. 2023 Jan 3. doi: 10.1097/SLA.0000000000005788. Epub ahead of print. PMID: 36594748.	To evaluate whether robotic for middle or low rectal cancer produces an improvement in surgical outcomes compared with laparoscopic surgery in a randomised controlled trial (RCT).	This trial showed no significant difference in total mesorectal excision (TME) quality between laparoscopic and robot-assisted surgery. No quality-of-life endpoint. This trial closed early due to low accrual - it is getting harder to get people to randomise laparoscopic surgery as robot-assisted surgery is becoming more widespread.
Petro CC, Zolin S, Krpata D, et al. Patient-Reported Outcomes of Robotic vs Laparoscopic Ventral Hernia Repair With Intraperitoneal Mesh: The PROVE-IT Randomised Clinical Trial. *JAMA Surg.* 2021;156(1):22–29. doi:10.1001/jamasurg.2020.4569	To determine whether robotic approach to ventral hernia repair with intraperitoneal mesh would result in less postoperative pain.	Laparoscopic and robotic ventral hernia repair with intraperitoneal mesh have comparable outcomes. The increased operative time and proportional cost of the robotic approach are not offset by a measurable clinical benefit.
Pundir J, Pundir V, Walavalkar R, Omanwa K, Lancaster G, Kayani S. Robotic-assisted laparoscopic vs abdominal and laparoscopic myomectomy: systematic review and meta-analysis. J Minim Invasive Gynecol. 2013 May-Jun;20(3):335-45. doi: 10.1016/j.jmig.2012.12.010. Epub 2013 Feb 27. PMID: 23453764.	A systematic review and meta-analysis of evidence related to operative outcomes associated with robotic assisted laparoscopic myomectomy (RLM) compared with abdominal myomectomy (AM) and laparoscopic myomectomy (LM). Outcome measures included estimated blood loss (EBL), blood transfusion, operating time, complications, length of hospital stay (LOHS), and costs.	It was concluded that insofar as operative outcomes, RLM has significant short-term benefits compared with AM and no benefits compared with LM. Long-term benefits such as recurrence, fertility, and obstetric outcomes remain uncertain.
Ramirez PT, Frumovitz M, Pareja R, Lopez A, Vieira M, Ribeiro R, Buda A, Yan X, Shuzhong Y, Chetty N, Isla D, Tamura M, Zhu T, Robledo KP, Gebski V, Asher R, Behan V, Nicklin JL, Coleman RL, Obermair A. Minimally Invasive versus Abdominal Radical Hysterectomy for Cervical Cancer. N Engl J Med. 2018 Nov 15;379(20):1895-1904. doi: 10.1056/NEJMoa1806395. Epub 2018 Oct 31. PMID: 30380365.	There are limited data from retrospective studies regarding whether survival outcomes after laparoscopic or robot-assisted radical hysterectomy (minimally invasive surgery) are equivalent to those after open abdominal radical hysterectomy (open surgery) among women with early-stage cervical cancer.	Minimally invasive radical hysterectomy was associated with lower rates of disease-free survival and overall survival than open abdominal radical hysterectomy among women with early-stage cervical cancer.

Rouanet P, Bertrand MM, Jarlier M, Mourregot A, Traore D, Taoum C, de Forges H, Colombo PE. Robotic Versus Laparoscopic Total Mesorectal Excision for Sphincter-Saving Surgery: Results of a Single-Center Series of 400 Consecutive Patients and Perspectives. Ann Surg Oncol. 2018 Nov;25(12):3572-3579. doi: 10.1245/s10434-018-6738-5. Epub 2018 Aug 31. PMID: 30171509.	The aim of this study is to compare robotic total mesorectal excision (R-TME) with laparoscopic TME (L-TME) in a series of consecutive rectal cancer patients.	R-TME is less likely to be converted to open surgery than L-TME; operative time and curative pathologic criteria are equivalent. Future prospective trials should compare standardised procedures performed by experienced surgeons for subgroups of high-risk patients.
Salehi S, Åvall-Lundqvist E, Brandberg Y, Johansson H, Suzuki C, Falconer H. Lymphedema, serious adverse events, and imaging 1 year after comprehensive staging for endometrial cancer: results from the RASHEC trial. Int J Gynecol Cancer. 2019 Jan;29(1):86-93. doi: 10.1136/ijgc-2018-000019. PMID: 30640688.	In the Robot Assisted Surgery for High Risk Endometrial Cancer (RASHEC) trial, patients with high-risk endometrial cancer were randomly assigned to robot-assisted laparoscopic surgery (RALS) or laparotomy for pelvic and infrarenal para-aortic lymph node dissection. We here report on self-reported lower limb lymphedema (LLL), lymphocyst formation, ascites, and long-term serious adverse events 12 months after surgery.	Follow-up 1 year after comprehensive surgical staging for high-risk endometrial cancer showed no differences in self-reported LLL, findings on imaging, or SAE between laparotomy and robot-assisted surgery.
Salehi S, Brandberg Y, Åvall-Lundqvist E, Suzuki C, Johansson H, Legerstam B, Falconer H. Long-term quality of life after comprehensive surgical staging of high-risk endometrial cancer - results from the RASHEC trial. Acta Oncol. 2018 Dec;57(12):1671-1676. doi: 10.1080/0284186X.2018.1521987. Epub 2018 Oct 5. PMID: 30289327.	The health-related quality of life (HRQoL) outcomes after comprehensive surgical staging including infrarenal paraaortic lymphadenectomy in women with high-risk endometrial cancer (EC) are unknown. Our aim was to investigate the long-term HRQoL between robot-assisted laparoscopic surgery (RALS) and laparotomy (LT).	Overall, laparotomy and robot-assisted surgery conferred similar HRQoL 12 months after comprehensive staging for high-risk EC.
Sarlos D, Kots L, Stevanovic N, von Felten S, Schär G. Robotic compared with conventional laparoscopic hysterectomy: a randomised controlled trial. Obstet Gynecol. 2012 Sep;120(3):604-11. doi: 10.1097/AOG.0b013e318265b61a. PMID: 22914470.	To compare conventional laparoscopic and robotic-assisted laparoscopic sacrocolpopexy for vaginal apex prolapse.	Robotic-assisted sacrocolpopexy results in longer operating time and increased pain and cost compared with the conventional laparoscopic approach.
Selber JC. Transoral robotic reconstruction of oropharyngeal defects: a case series. Plast Reconstr Surg. 2010 Dec;126(6):1978-1987. doi: 10.1097/PRS.0b013e3181f448e3. PMID: 21124136.	Large resections of oropharyngeal tumours in the absence of a mandibulotomy create a reconstructive challenge, because flaps are often necessary, and inset requires contouring and suturing in a confined space with limited line of sight. Transoral robotically assisted	Minimally invasive resections provide locoregional control without the morbidity of mandibulotomy or high dose chemoradiation. Transoral robotic reconstruction allows access and precision within the oropharynx. It is safe

	reconstruction is the logical solution.	and effective and may expand minimally invasive resections where reconstruction is not possible through traditional approaches.
Terho AM, Mäkelä-Kaikkonen J, Ohtonen P, Uimari O, Puhto T, Rautio T, Koivurova S. Robotic versus laparoscopic surgery for severe deep endometriosis: protocol for a randomised controlled trial (ROBEndo trial). BMJ Open. 2022 Jul 18;12(7):e063572. doi: 10.1136/bmjopen-2022-063572. PMID: 35851028; PMCID: PMC9297206.	The objective of this study is to examine whether robot-assisted laparoscopy is superior compared with conventional laparoscopy as regard to patient outcome immediately after surgery, as well as at 6, 12 and 24 months postoperatively, measured by questionnaires concerning the pain symptoms and disease-related quality-of-life.	Robotics serves a flexible platform for multidisciplinary approach with advantages in deep and precise dissection in female pelvis, that may allow a more radical excision of the disease and a better long-term outcome for the patient. Increased knowledge on the possibilities of gynaecological robotic surgery may help medical professionals in decision making concerning patient selection as well as resource and cost management.
van der Sluis PC, van der Horst S, May AM, Schippers C, Brosens LAA, Joore HCA, Kroese CC, Haj Mohammad N, Mook S, Vleggaar FP, Borel Rinkes IHM, Ruurda JP, van Hillegersberg R. Robot-assisted Minimally Invasive Thoracolaparoscopic Esophagectomy Versus Open Transthoracic Esophagectomy for Resectable Oesophageal Cancer: A Randomised Controlled Trial. Ann Surg. 2019 Apr;269(4):621-630. doi: 10.1097/SLA.0000000000003031. PMID: 30308612.	The standard curative treatment for patients with oesophageal cancer is perioperative chemotherapy or preoperative chemoradiotherapy followed by open transthoracic esophagectomy (OTE). Robot-assisted minimally invasive thoracolaparoscopic esophagectomy (RAMIE) may reduce complications.	RAMIE resulted in a lower percentage of overall surgery-related and cardiopulmonary complications with lower postoperative pain, better short-term quality of life, and a better short-term postoperative functional recovery compared to OTE. Oncological outcomes were comparable and in concordance with the highest standards nowadays.

APPENDIX 3
PROPOSED ROBOT-ASSISTED SURGERY EVALUATION FORM
TO BE COMPLETED BY PROCTOR

ROBOTIC SURGERY EVALUATION FORM

Name of the Surgeon	
Name of the Proctor	
Date of surgery	
Procedure performed	
Patient's name	
Was the surgery performed for an appropriate indication? Yes/No. If no, discuss.	
Was the pre-operative work-up adequate? Yes/No. If no, discuss.	

Please note, for the following questions:
A rating of **1-5** denotes that further proctoring is necessary for the surgeon to progress to Step 2: Provisionally Accredited Robotic Surgeon
A rating of **6-10** denotes that the surgeon is sufficiently competent to progress to Step 2: Provisionally Accredited Robotic Surgeon

Please rate the surgeon's port placement and docking of the robotic platform.	1------2------3------4------5------6------7------8------9------10
Comments, if any:	
Please rate the surgeon's knowledge of the surgical anatomy and the steps of the surgery.	1------2------3------4------5------6------7------8------9------10
Comments, if any:	
Please rate the surgeon's fluency with the use of the robotic platform.	1------2------3------4------5------6------7------8------9------10
Comments, if any:	
Please rate the surgeon's competence during this surgery, for the surgeon's level of experience with Robotics.	1------2------3------4------5------6------7------8------9------10
Comments, if any:	
Does the surgeon require proctoring for their cases in future? Yes/ No.	

If applicable, is the surgeon's competency sufficient to receive provisional privileges? Yes/No	
Comments, if any:	
Proctor's signature	
Date	
Proctor's name	
Address	
Suburb	
Postcode	
Phone number	

APPENDIX 4
ROBOT-ASSISTED SURGERY WORKING PARTY MEMBERSHIP

Prof Henry Woo	Chair
Dr Aubrey Almeida	Cardiothoracic representative
Dr Sanket Srinivasa	General surgery representative
Dr Sharon Lee	Neurosurgery representative
Dr Veronika Van Dijck	Otolaryngology Head and Neck, AoNZ representative
Dr Bhavesh Patel	Paediatric representative
Dr Alessandra Canal	Plastic and reconstructive representative
Dr Rick Catterwell	Urology representative
Dr Benjamin Ho	Trainee representative
Dr Warren Hargreaves	Skills Education representative
Associate Prof Alan Lam	RANZCOG representative
Dr Alastair McLean	MTAA representative
Dr Kesley Pedler	Rural representative
Dr Claire Langdon	Community advisor
Dr Helen Mohan	Medical educator
Dr Tamsin Garrod	EGM - Education Development and Delivery
Ms Christine Cook	EGM - Education Partnerships
Ms Hayley Allen	Secretary, Education Lead – Digital Implementation and Commercialisation

REFERENCES

1. McKensey S. RACS Robot-assisted Surgery working party request for information to May 2023. 2023.

2. Sinha A, West A, Vasdev N, Sooriakumaran P, Rane A, Dasgupta P, et al. Current practises and the future of robotic surgical training. The Surgeon [Internet]. 2023 Mar [cited 2023 Jun 5];S1479666X23000343. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1479666X23000343

3. Da Vinci Robot Patency 2019 [Internet]. Da Vinci Robot Patency 2019. Intuitive Surgical Company; Available from: https://www.intui tive.com/en-us/about -us/company/legal/patent-notice

4. Almujalhem A, Rha KH. Surgical robotic systems: What we have now? A urological perspective. BJUI Compass [Internet]. 2020 Nov [cited 2023 Jun 5];1(5):152–9. Available from: https://onlinelibrary.wiley.com/doi/10.1002/bco2.31

5. McDonald CR, Kozman MA, Tonkin D, Eteuati J, Karatassas A. Training for robotics in general surgery: is it where it should be?: Perspectives. ANZ Journal of Surgery [Internet]. 2018 Jun [cited 2023 Jun 5];88(6):530–1. Available from: https://onlinelibrary.wiley.com/doi/10.1111/ans.14400

6. Ahmed K, Khan R, Mottrie A, Lovegrove C, Abaza R, Ahlawat R, et al. Development of a standardised training curriculum for robotic surgery: a consensus statement from an international multidisciplinary group of experts. BJU Int [Internet]. 2015 Jul [cited 2023 Jun 5];116(1):93–101. Available from: https://onlinelibrary.wiley.com/doi/10.1111/bju.12974

7. Smith R, Patel V, Satava R. Fundamentals of robotic surgery: a course of basic robotic surgery skills based upon a 14-society consensus template of outcomes measures and curriculum development: Fundamentals of robotic surgery. Int J Med Robotics Comput Assist Surg [Internet]. 2014 Sep [cited 2023 Jun 5];10(3):379–84. Available from: https://onlinelibrary.wiley.com/doi/10.1002/rcs.1559

8. USANZ - National Workshop for Surgical Robotics [Internet]. [cited 2023 Jun 5]. Available from: https://www.usanz.org.au/news-updates/our-announcements/national-workshop-for-surgical-robotics

9. Cameron A, Tivey D. Training for robot-assisted surgery: A preliminary scoping exercise. Royal Australasian College of Surgeons; 2022 Apr.

10. O'Connell LV, Hayes C, Ismail M, O'Ríordáin DS, Hafeez A. Attitudes and access of Irish general surgery trainees to robotic surgical training. Surgery Open Science [Internet]. 2022 Jul [cited 2023 Jun 5];9:24–7. Available from: https://linkinghub.elsevier.com/retrieve/pii/S2589845022000161

11. Health C for D and R. Update: caution with robotically-assisted surgical devices in mastectomy: fda safety communication. FDA [Internet]. 2021 Aug 20 [cited 2023 Jun 5]; Available from: https://www.fda.gov/medical-devices/safety-communications/update-caution-robotically-assisted-surgical-devices-mastectomy-fda-safety-communication

12. Hickie D. 'Surgeon' to be protected title in Australian national law [Internet]. Aesthetic Medical Practitioner. [cited 2023 Jun 5]. Available from: https://aestheticmedicalpractitioner.com.au/features/cosmetic-practice/surgeon-to-be-protected-title-in-australian-national-law/#:~:text=%E2%80%99Surgeon%E2%80%99%20to%20become%20protected%20title,title%20in%20the%20national%20law.

13. Use of the title, 'surgeon' to be restricted [Internet]. [cited 2023 Jun 5]. Available from: https://www.surgeons.org/News/media-releases/Use of the title surgeon to be restricted

14. A Wellbeing Charter for Doctors [Internet]. 2021 Jul. Available from: https://www.surgeons.org/-/media/Project/RACS/surgeons-org/files/reports-guidelines-publications/manuals-guidelines/2021-07-19-PUB-Wellbeing-Charter-for-Doctors---Final.pdf?rev=384f2da871274587a05f53c4f921b679&hash=B4E4C7F4FC91AE7F5BB29A7C489DB869

15. The Joint Commission, Division of Health Care Improvement. Quick Safety 3: Potential risks of robotic surgery. Quick Safety [Internet]. Issue Three June 2014. 2021 Mar; Available from: https://www.jointcommission.org/resources/news-and-multimedia/newsletters/newsletters/quick-safety/quick-safety-issue-3-potential-risks-of-robotic-surgery/potential-risks-of-robotic-surgery/

16. Department of Anaesthesiology, Civil Hospital Sector-6, Panchkula, Haryana, India, Kapur A, Kapur V, Department of Medicine, H S Judge Institute of Dental Sciences, Panjab University, Chandigarh (UT), India. Robotic surgery: anaesthesiologist's contemplation. MJMS [Internet]. 2020 Jun 30 [cited 2023 Jun 5];27(3):143–9. Available from: http://www.mjms.usm.my/MJMS27032020/15MJMS27032020_BC.pdf

17. Abbas AE, Sarkaria IS. Specific complications and limitations of robotic esophagectomy. Diseases of the Esophagus [Internet]. 2020 Nov 26 [cited 2023 Jun 5];33(Supplement_2):doaa109. Available from: https://academic.oup.com/dote/article/doi/10.1093/dote/doaa109/6006411

18. Silva JB, Busnello CV, Cesarino MR, Xavier LF, Cavazzola LT. Is there room for microsurgery in robotic surgery? Rev Bras Ortop (Sao Paulo). 2022 Oct;57(5):709–17.

19. Lanfranco AR, Castellanos AE, Desai JP, Meyers WC. Robotic surgery: a current perspective. Ann Surg. 2004 Jan;239(1):14–21.

20. Truong MD, Tholemeier LN. Role of robotic surgery in benign gynecology. Obstet Gynecol Clin North Am. 2022 Jun;49(2):273–86.

21. Shugaba A, Lambert JE, Bampouras TM, Nuttall HE, Gaffney CJ, Subar DA. Should all minimal access surgery be robot-assisted? A systematic review into the musculoskeletal and cognitive demands of laparoscopic and robot-assisted laparoscopic surgery. J Gastrointest Surg. 2022 Jul;26(7):1520–30.

22. Robotic surgery training begins at RCSI [Internet]. 2022 [cited 2023 Jun 5]. Available from: https://www.rcsi.com/dublin/news-and-events/news/news-article/2022/10/robotic-surgery-training-begins-at-rcsi

23. Development of new robotic surgical services: A guide to good practice [Internet]. The Royal College of Surgeons of Edinburgh; 2022 May. Available from: https://www.rcsed.ac.uk/media/683822/rcsed-robotics-guidance-document-final.pdf

24. Prideaux D. ABC of learning and teaching in medicine. Curriculum design. BMJ. 2003 Feb 1;326(7383):268–70.

25. My Intuitive [Internet]. Intuitive Surgical; [cited 2023 Jun 5]. Available from: https://www.intuitive.com/en-us/products-and-services/my-intuitive

26. News. UC Davis Health performs first robotic nephrectomy on living kidney donor [Internet]. news. [cited 2023 Jun 6]. Available from: https://health.ucdavis.edu/news/headlines/uc-davis-health-performs-first-robotic-nephrectomy-on-living-kidney-donor/2023/04

27. Patel E, Mascarenhas A, Ahmed S, Stirt D, Brady I, Perera R, et al. Evaluating the ability of students to learn and utilize a novel telepresence platform, proximie. European Urology Open Science [Internet]. 2021 Nov [cited 2023 Jun 5];33:S136–8. Available from: https://linkinghub.elsevier.com/retrieve/pii/S2666168321023144

28. Board of surgical education & training [Internet]. [cited 2023 Jun 5]. Available from: https://www.surgeons.org/about-racs/about-the-college-of-surgeons/governance-committees/training-education-examinations-committees/committee-of-surgical-education-training

29. RACS Professional Skills Curriculum [Internet]. Royal Australasian College of Surgeons; [cited 2023 Jun 5]. Available from: https://www.surgeons.org/-/media/Project/RACS/surgeons-org/files/Professional-Skills-Curriculum/Professional-Skills-Curriculum-2023.pdf

30. Updated surgical competence and performance guide [Internet]. Royal Australasian College of Surgeons; Available from: https://www.surgeons.org/News/News/Updated Surgical Competence and Performance Guide

31. The Australian Society of Specialist General Surgeons. CTEC Skills Training Courses [Internet]. Available from: https://www.generalsurgeons.com.au/education-and-training/skills-courses/ctec-skills-training-courses

32. Intuitive announces UK-first robotic-assisted surgery training program in partnership with Newcastle Surgical Training Centre [Internet]. News-Medical.net. 2023 [cited 2023 Jun 13]. Available from: https://www.news-medical.net/news/20230610/Intuitive-announces-UK-first-robotic-assisted-surgery-training-program-in-partnership-with-Newcastle-Surgical-Training-Centre.aspx

33. Chahal B, Aydın A, Amin MSA, Ong K, Khan A, Khan MS, et al. Transfer of open and laparoscopic skills to robotic surgery: a systematic review. J Robot Surg. 2022 Nov 22;

34. Harji D, Aldajani N, Cauvin T, Chauvet A, Denost Q. Parallel, component training in robotic total mesorectal excision. J Robot Surg. 2023 Jun;17(3):1049–55.

35. Waters PS, Flynn J, Larach JT, Fernando D, Peacock O, Foster JD, et al. Fellowship training in robotic colorectal surgery within the current hospital setting: an achievable goal? ANZ J Surg. 2021 Nov;91(11):2337–44.

36. Lovegrove C, Ahmed K, Novara G, Guru K, Mottrie A, Challacombe B, et al. Modular training for robot-assisted radical prostatectomy: where to begin? J Surg Educ. 2017;74(3):486–94.

37. Yang JH, Goodman ED, Dawes AJ, Gahagan JV, Esquivel MM, Liebert CA, et al. Using AI and computer vision to analyze technical proficiency in robotic surgery. Surg Endosc. 2023 Apr;37(4):3010–7.

38. Nakane K, Yamada T, Tomioka-Inagawa R, Sugino F, Kumada N, Kawase M, et al. Efficacy and safety of the ‘trisection method’ training system for robot-assisted radical cystectomy at a single institution in japan. Curr Oncol. 2022 Nov 29;29(12):9294–304.

39. The Royal College of Surgeons of Edinburgh. Development of new robotic surgical services: A guide to good practice [Internet]. 2022 May. Available from: https://www.rcsed.ac.uk/media/683822/rcsed-robotics-guidance-document-final.pdf

40. Rulli F, Maura A, Galatà G, Olivi G, Grande M, Farinon AM. A dry lab for medical engineers? Ann Surg Innov Res. 2009 Jul 31;3:9.

41. Andolfi C, Patel D, Rodriguez VM, Gundeti MS. Impact and outcomes of a pediatric robotic urology mini-fellowship. Front Surg. 2019;6:22.

42. Australian Commission on Safety and Quality in Health Care. Clinical governance standard [Internet]. Available from: https://www.safetyandquality.gov.au/standards/nsqhs-standards/clinical-governance/clinical-governance-standard

43. Huffman EM, Rosen SA, Levy JS, Martino MA, Stefanidis D. Are current credentialing requirements for robotic surgery adequate to ensure surgeon proficiency? Surg Endosc. 2021 May;35(5):2104–9.

44. Australian Commission on Safety and Quality in Health Care. Credentialing health practitioners and defining their scope of clinical practice: A guide for managers and practitioners [Internet]. 2015. Available from: https://www.safetyandquality.gov.au/publications-and-resources/resource-library/credentialing-health-practitioners-and-defining-their-scope-clinical-practice-guide-managers-and-practitioners

45. Wang RS, Ambani SN. Robotic surgery training: current trends and future directions. Urol Clin North Am. 2021 Feb;48(1):137–46.

46. AAGL Advancing Minimally Invasive Gynecology Worldwide. Guidelines for privileging for robotic-assisted gynecologic laparoscopy. J Minim Invasive Gynecol. 2014;21(2):157–67.

47. Bhora FY, Al-Ayoubi AM, Rehmani SS, Forleiter CM, Raad WN, Belsley SG. Robotically assisted thoracic surgery: proposed guidelines for privileging and credentialing. Innovations (Phila). 2016;11(6):386–9.

48. Brinkman WM, Luursema JM, Kengen B, Schout BMA, Witjes JA, Bekkers RL. Da vinci skills simulator for assessing learning curve and criterion-based training of robotic basic skills. Urology. 2013 Mar;81(3):562–6.

49. Panteleimonitis S, Miskovic D, Bissett-Amess R, Figueiredo N, Turina M, Spinoglio G, et al. Short-term clinical outcomes of a European training programme for robotic colorectal surgery. Surg Endosc. 2021 Dec;35(12):6796–806.

50. Younes MM, Larkins K, To G, Burke G, Heriot A, Warrier S, et al. What are clinically relevant performance metrics in robotic surgery? A systematic review of the literature. J Robot Surg. 2023 Apr;17(2):335–50.

51. Sánchez R, Rodríguez O, Rosciano J, Vegas L, Bond V, Rojas A, et al. Robotic surgery training: construct validity of global evaluative assessment of robotic skills(Gears). J Robot Surg. 2016 Sep;10(3):227–31.

52. Hung AJ, Bottyan T, Clifford TG, Serang S, Nakhoda ZK, Shah SH, et al. Structured learning for robotic surgery utilizing a proficiency score: a pilot study. World J Urol. 2017 Jan;35(1):27–34.

53. CPD standard and guidelines [Internet]. [cited 2023 Jun 5]. Available from: https://www.surgeons.org/Fellows/continuing-professional-development/cpd-standard-and-guidelines

54. Australia. High Court. Rogers v. Whitaker. Aust Law J. 1993 Jan;67(1):47–55.

55. McCaw S. Grampians Health installs state-of-the-art surgical robot in Ballarat [Internet]. Grampians Health. 2023 [cited 2023 Jun 5]. Available from: https://grampianshealth.org.au/2023/02/grampians-health-installs-state-of-the-art-surgical-robot-in-ballarat/

56. Lindenberg MA, Retèl VP, Van Der Poel HG, Bandstra F, Wijburg C, Van Harten WH. Cost-utility analysis on robot-assisted and laparoscopic prostatectomy based on long-term functional outcomes. Sci Rep [Internet]. 2022 May 10 [cited 2023 Jun 7];12(1):7658. Available from: https://www.nature.com/articles/s41598-022-10746-3

Royal Australasian
College of Surgeons