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Transoral robotic surgery in head neck cancer management

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Abstract. *Transoral robotic surgery in head neck cancer management*. Head and Neck cancer can be treated by non-surgical or surgical modalities. Current surgical techniques include open surgery and transoral resections. The latter have the distinct advantage of quicker recovery and reduced hospital stay. The further down the aerodigestive tract tumours are sited, the more difficult is the transoral access, requiring techniques that combine magnification and finer instrumentation. Thus, while oral cavity tumours can be removed transorally without special equipment, the need to address oropharyngeal and laryngeal cancers led to the evolution of transoral laser microsurgery. Transoral robotic surgery (TORS) improves the visualisation, the instrumentation and the ergonomics in transoral resections and is also used primarily in the treatment of oropharyngeal and laryngeal cancer. Current evidence suggests that the oncologic and functional outcome of TORS surgery is good as speech and swallowing mechanisms are better preserved. This review will provide the reader an insight into the role of TORS in head and neck practice.

Introduction

The treatment modalities commonly used for Head and Neck cancer (HNC) include radiotherapy (with or without chemotherapy) and surgery, or both. Surgical options include open surgery with or without reconstruction and transoral laser microsurgery (TLM). The latest addition to this list is transoral robotic surgery (TORS). TORS was first performed on patients with base of tongue and tonsil tumours in 2006 and 2007 respectively.[1,2] With the publication of increasing amount of data on this modality, cancer centres across the world have embraced the technology in greater numbers.

The most common interface used to perform TORS is the da Vinci System, named after the great inventor who developed the world's first robot.[3] For the purposes of this review, as the overwhelming majority of published data is based on the da Vinci system, the discussion will confine itself to this system. The da Vinci robotic system consists of 3 independent components; the robotic cart, the surgeon's console, and the vision cart. The robotic cart comprises of three arms, on which are mounted the camera and two EndoWrist® instruments; the latter includes a wide choice of several instrument tips, but the 5mm monopolar electrocautery spatula and a Maryland dissector are the most common ones used for TORS. The EndoWrist® technology allows for 7 degrees of freedom and 90 degrees of articulation. The camera comprises of a dual rigid telescope that provides 3-dimensional vision at the console and also projects the image to the vision cart. At the console, situated remotely from the patient, the surgeon views a three dimensional image of the operating field and operates the EndoWrist ® and camera system via joysticks and foot controls. The console has an inbuilt system to filter out hand tremor. The vision cart supports a high definition monitor from which the bedside assistant and the rest of the theatre staff are able to see the operating field. The scrubbed surgical assistant who is key to optimising the surgical field, sits at the head end of the patient, usually with two instruments in the oral cavity performing suction and retraction.[4]

Rationale for incorporating TORS in the management

1. *The pendulum shift away from open surgery*

Over the last 4 decades, the head and neck surgical community has veered away from open surgery for primary oropharyngeal cancer and early to intermediate staged laryngeal cancer. Open surgical procedures lead to longer post-operative rehabilitation periods with significant effects on speech and swallow function. A large review of over 6000 patients showed that open surgery in oropharyngeal cancer did not offer superior tumour

control and often led to greater morbidity.[5] With the advent of the organ preservation paradigms, further data emerged to support concurrent chemotherapy with radiation in these tumours, with similar outcomes.[6] Over the last 2 decades primary chemoradiation has become the mainstay of treatment for oropharyngeal cancer, but long term follow up data show that significant functional deficits persist.[7,8] Robust data on functional outcomes following intensity modulated radiation therapy where swallowing related structures are spared is awaited, although early results are encouraging.[9] Thus, the functional results following organ preservation approaches have been the key drivers for newer techniques in transoral surgery.

2. *Transoral resections*

These approaches offer the advantage of resecting malignant lesions without disrupting the neck anatomy, which translates into early resumption of function and shorter postoperative stay. While TLM has been widely used for HNC treatment, there have been some limitations which have precluded widespread use. As the surgeon is limited to working in the "line of sight", some cancer sites such as the tongue base are not easily excised. In addition, teaching TLM for larger tumours is especially challenging. The most significant advantage that TORS confers over other surgical options is better visualisation of the tumour site, the ability to work in a wide field that is not necessarily within "line of sight", in an ergonomic setting that often leads to a quicker operation. The presence of four operating arms (two robotic instruments and two from the surgical assistant at the bedside) offers an unparalleled ability to retract tissues and work around the tumour from multiple angles in order to obtain an optimal, often, "en bloc" resection. Teaching TORS is relatively easy given the better visualisation and dual control surgeon consoles which allow the controls to be shared with the trainee surgeon. TORS can be performed quicker than conventional transoral surgery. Park *et al*. reported an average surgical time of 39 minutes for TORS surgery in laryngeal and hypopharyngeal cancer,[4] conventional open surgery may involve mandibulotomy with reconstruction which can last for several hours. Hospital stay is also much shorter compared to open surgery. The reported average hospital stay was 4.2 days.[10]

3. *Transoral resections and adjuvant radiation*

A primary surgical approach allows the treating team to accurately stage the primary tumour site; as most primary sites require a bilateral neck dissection, this provides pathological staging of both necks. Assessment of surgical margins, identifying the presence or absence of extracapsular spread and other poor prognostic factors allows appropriate tailoring of adjuvant treatment. In the absence of extracapsular spread and positive margins, adjuvant radiation alone is needed and concurrent chemotherapy can be omitted. The adjuvant radiation dose is considerably less compared to primary chemoradiation, often will need to be delivered to one side of the neck only following pathological staging, is thus associated with less toxicity and quicker functional recovery.[10]

4. *Functional outcomes after transoral surgery*

Good functional outcomes have been demonstrated in prospective cohorts with a policy of primary surgery followed by adjuvant treatment as necessary. In a cohort of 89 patients with head and neck cancer treated with TORS, White *et al*. reported that no patient needed gastrostomy tube post operatively.[11] In a study of 177 patients with oropharyngeal and laryngeal cancer, Weinstein *et al*. showed only 5% of patients used long term gastrostomy tube. In the same cohort, 22 out of the 177 patients (12.4%) had elective tracheostomy but only 4 patients (2.3%) still needed tracheostomy at 12 months follow up.[10] A systematic review of oropharyngeal cancer managed by TORS and postoperative radiation therapy showed that only 2 out of the 411 cases were lifelong tracheostomy users and the proportion of patients requiring gastrostomy feeding post operatively is lower than for patients who underwent primary chemo-radiotherapy.[12]

Role in oropharynx cancer

1. *Early oropharyngeal cancer*

The oropharynx plays an important part in speech and swallowing, making surgical treatment of this anatomical region challenging. TORS is currently widely used in the management of oropharyngeal cancer staged T1 and T2. National guidelines from the UK and USA support the philosophy of transoral resection over open surgery.[13]

2. *Advanced disease*

TORS is currently not used routinely in the management of advanced oropharyngeal disease, where the standard of care continues to be primary chemoradiation therapy. In selected cases, where it is deemed that adequate resection could be performed in larger tumours with good functional results, TORS has shown good oncological outcomes when combined with adjuvant treatment.

3. *Pre-operative considerations*

Careful patient selection is key to achieving good oncologic outcomes. The current indications for TORS on oropharyngeal cancer include resectable disease with negative margins, thus defining its applicability in early stage cancer of the tonsils (T1-2).[4] Negative margins would obviate the need for radiation therapy.[14] One should be able to visualise the tumour adequately via the mouth. Exposure can be limited by trismus, large tongue and high BMI. Contraindications include fixed tumour invading the mandible, unresectability of involved neck nodes, resection requiring more that 50% of the tongue base, resection requiring more than 50% of the posterior pharyngeal wall, carotid artery involvement and fixation of the tumour to prevertebral fascia. In addition, the presence of a retropharyngeal carotid artery is a contraindication to resection of tonsil tumours by TORS.

4. *Operative considerations*

4.1. TORS for tonsil tumours

The recommended procedure for T1 and T2 tonsil cancers is a lateral oropharyngectomy. In this procedure, the tonsil is removed along with the superior constrictor muscle laterally, a cuff of tongue base tissue between the tonsillar pillars inferiorly and the superomedial aspect of the soft palate superiorly. This ensures an "en bloc" resection that when pathologically assessed, yields a negative margin in the vast majority of patients.

4.2. TORS for tongue base tumours

For T1 and T2 tongue base cancers, an "en bloc" tongue base hemiglossectomy is the recommended procedure. This involves resection of the tongue base from the tonsillo-lingual sulcus to the midline, and from the circumvallate papillae to the vallecula, with an adequate cuff of normal tissue in all 3 dimensions.

5. *Outcomes*

The reported outcomes of TORS surgery with respect to negative margins is very encouraging. Weinstein *et al*. showed in a multicentre study of 177 patients a positive margin rate of 4.3%, indicating wide acceptability and take up of this technique.[10] The overall survival rates reported in current literature for stage I tumours can reach up to 89%.[15]

Role in larynx cancer

1. *Early cancer*

TORS is currently widely used in the management of T1 and T2 supraglottic cancer. National guidelines from the UK and USA support the philosophy of transoral resection over open surgery.[13]

2. *Advanced disease*

TORS is currently not used routinely in the management of advanced laryngeal disease, where the standard of care continues to be primary chemoradiation therapy or open total laryngectomy. There is also emerging experience for transoral robotic assisted total laryngectomy via a TORS approach in selected patients.[16]

3. *Pre-operative considerations*

Most of the current literature on the use of TORS in laryngeal cancer concerns supraglottic tumours.[17] There is currently reasonable evidence to support transoral surgery for supraglottic cancers from prospective series and database reviews.[18-20] Compared to TLM, TORS provides a better view of the anterior commissure. A case series of three patients demonstrates success in treatment for laryngeal cancer with TORS in cases where TLM had failed due to limited exposure.[21]

4. *Operative considerations and contraindications*

The TORS supraglottic laryngectomy involves resection of the involved supraglottis with an adequate margin of normal tissue. Supraglottic tumours T1 to T2 are amenable to resection by TORS. It is recommended that electrocautery is not be used in glottic surgery because injury from the heat may cause bilateral vocal cord palsy and result

in life-long tracheostomy. Therefore, it has been suggested that tumours extending into the paraglottic area should not be treated by TORS.[17] Exposure is the most important pre operative consideration for TORS in laryngeal cancer. Patients with trismus are not be eligible for TORS as poor mouth opening would cause the instrument arms to interfere with each other's movements as they reach the depths of the pharynx and larynx. This is particularly problematic as TORS instruments are bulkier than TLM instruments. Exposure can also be compromised by the presence of prominent upper front teeth, high arched palate and retrognathic mandibles.[17]

5. *Outcomes*

At the end of a 2-year follow-up period of 18 patients who underwent TORS for supraglottic tumours, Mendelsohn *et al*. reported locoregional control, disease-specific survival, and overall survival rates of 83%, 100%, and 89%.[22] Park *et al*. also reported a disease free survival rate of 91% in a cohort of 16 patients.[23] The rate of positive margins is also very low as seen in a review of 4 out of 5 studies with a positive margin rate of 0%. The percentage of patients needing gastrostomy tube post operatively was also 0% in 3 out of those 5 studies. Park *et al*. inserted a tracheostomy in all their 16 patients. By contrast, 2 other studies of 13 and 18 patients reported a 0% rate of tracheostomy.[15]

Role in nasopharynx cancers

Radiotherapy with or without chemotherapy have traditionally treated early nasopharyngeal carcinoma successfully. However, the recurrence rate is still high. Recurrence is thought to arise from residual cancer cells, unfortunately, these cells are resistant to chemotherapy. TORS allows for en bloc resection of some of these radio recurrent tumours, if the margins are negative, there is a lower risk of leaving cancer cells behind. This will help to reduce the rate of recurrence and avoid further chemotherapy or even open surgery.[24]

Role in unknown primaries

Around 2-4% of all the head and neck cancers with lymph node metastases have an unknown primary. Until now TLM has proved to be the most effective method of identifying the primary disease in these cases. However, with the three dimensional images provided by the TORS, robotic surgery may prove to be a valuable asset in identifying the primary sites. The surgeon is able to assess the mucosal changes with more precision.[25]

Traditionally, the diagnosis would be made based on clinical history and examination, outpatient flexible endoscopy, panendoscopy under general anaesthetic and imaging. Imaging is usually in the form of CT or PET-CT. Despite thorough investigation, diagnosis evades the MDT in more than 40% of cases. Moreover, PET-CT carries a false positive rate of 28%. Therefore, wide-field chemoradiotherapy is often indicated in these patients. A series by Dumus *et al*. (2013) showed that the use of TORS improved their detection rate by 18% as compared to panendoscopy with imaging. This is particularly useful as complete excision of the lesion by TORS allows for a smaller radiation field and lower radiation dose, precluding the need for chemotherapy. Side effects are thus minimised.[25]

Role in skull base surgery

The introduction of TORS techniques in skull base surgery has been slow to catch up with its application in pharyngeal and laryngeal cancers. In recent years, transnasal endoscopic approach has become the most favoured technique for accessing lesions of the anterior and central skull base. The reason for its rising popularity is that it allows the surgeon to access these deep structures without the need for craniofacial incisions. The use of endoscope also allows for a wider angle of vision compared to microscopes. TORS could become a serious contender to the transnasal endoscopic approach. It does provide some serious advantages which are mentioned below. Further studies are required to define the role of robotic surgery in skull base operations.[26]

1. *Optical advantages*

The Da Vinci system allows for 3D visualisation of the operating field while the endoscope only provides a two dimensional image. The improved perception of depth conferred by the 3D image is particularly useful when working on important

neurovascular structures in a confined operating space.

2. *Ergonomic gains*

TORS allows the surgeon to be in control of both the instruments and camera. Endoscopic resection of base of skull tumours rely on two surgeons as an assistant is required to control the endoscope. Also, the da Vinci system has a unique feature of eliminating tremor during instrumentation.

3. *Reconstructive advantages*

One of the main difficulties that skull base surgeons face using the endoscopic approach is the inability to provide watertight dural closure and reconstruction of dural defects. Robotic surgery can help to overcome this problem as 3D visualisation allows the surgeon to place secure sutures in confined spaces of the skull base.

4. *Dissection limitations*

Transnasal endoscopic surgery does have one advantage over TORS; current TORS instruments have been designed to manipulate soft tissues, the dissection of bony structures significantly shortens their life span.

Complications of TORS

While most studies have highlighted the advantages of TORS compared to traditional modes of surgery, few studies have looked into the complications of TORS. A survey conducted by Chia *et al*.[27] in 2013 received responses from 45 surgeons who have collectively performed 2015 TORS procedures. The most common complication was bleeding (3.1%), followed by dehydration. Other complications included extended period of reliance on gastrostomy feed (more than 6 months), temporary hypoglossal nerve injury and lingual nerve injury. The mortality rate within 30 days of operation was 0.3% and was entirely due to post operative haemorrhage.[27]

Potential problems and disadvantages of TORS

One of the main problems encountered by centres wishing to acquire the Da Vinci system is the cost of the technology and specialist training. The cost of the Da Vinci can be justified if it is used by more than one specialty.[28] Moreover, shorter hospital stays and rapid rehabilitation should lead to cost savings over time, which will balance out its initial cost. The initial problem that many centres have faced using the Da Vinci system is the increased time it takes to set up all the different components. However, as the theatre staff get more accustomed to the use of the Da Vinci, this time can be significantly reduced.[28]

Future prospects

1. *Skills and equipment*

The Da Vinci system is still a new concept and we are still at the beginning of the learning curve. As such, surgical techniques still have to be refined with increased exposure and experience. The instruments used can also be further developed to suit the needs of head and neck surgeons depending on the anatomical region to be operated on. The addition of fibres allowing for laser treatment in TORS can make laryngeal surgery safer and reduce the risk of intra and postoperative bleeding.[17]

2. *Further studies*

There are randomised controlled trials of TORS in the management of head and neck cancer currently under way.[29] These will help to provide stronger evidence to confirm the benefits of TORS over other forms of surgical and non surgical options. Further prospective studies are also needed to provide more clear-cut indications and contraindications for the role of TORS in head and neck cancer for each anatomical location and stage of disease.

3. *Telesurgery*

Telesurgery has yet to be used in head and neck surgery. However, Marescaux and colleagues have proved that telesurgery is possible by performing a cholecystectomy on a patient in France while based in New York. This would be particularly befitting in a military situation or in remote locations where surgeons are not on site. TORS should be prospectively compared with traditional surgical or non surgical options for each tumor location and stage to determine its specific role.[4]

4. *Training*

4.1. Training the surgeon

Training surgeons with no prior experience of TORS surgery on live patients may compromise patient safety. Therefore, it would be most appropriate for the trainee surgeons to gain the skills required in robotic surgery outside of the operating theatre first. This can take the form of cadaveric courses or simulated training.[4] Lerner *et al*. has shown from their study that training using a simulator yielded similar results as training on the actual Da Vinci system.[30] This is especially relevant as the number of TORS procedures is limited and hence limits the trainees exposure. Another form of training involves the use of dual console da Vinci system where both the trainer and the trainee can have control of the instruments.[4]

4.2. Assessment of training

As of yet, there are no standardised assessment of a trainee's competency in TORS procedures in the UK. However, it is reasonable to suggest that trainee proficiency in TORS would increase with exposure and practice. Goh et al have developed a standardised tool to assess a trainee's competency in urology called Global Evaluative Assessment of Robotic Skills (GEARS).[31] However, the tool which assesses depth perception, bimanual dexterity, efficiency, force sensitivity, autonomy, and robotic control is not limited to urological procedures and could potentially be transferred to head and neck surgery.[4]

4.3. Training the team[14]

The Da Vinci system needs the whole theatre staff to be familiar with the system. It is a new and complex technology which can create some apprehension when being first introduced, which usually stems from preconceived ideas regarding TORS. Nurse education of TORS should include lecture based teachings to cover topics such as rationale of TORS, the layout of the room and definition of each person's role.

Conclusion

Despite a short gestation period, TORS has shown itself to be of significant value in head and neck cancer surgery. Further refinements in technology and newer models are inevitable and we anticipate an increasing role for this modality in the future.

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