Intraoperative Ultrasonography During Transoral Robotic Surgery

Daniel Clayburgh MD PhD, J. Ken Byrd MD, Jennifer Bonfili BSN RN, Umamaheswar Duvvuri MD PhD

Department of Otolaryngology—Head and Neck Surgery, University of Pittsburgh Medical Center, Pittsburgh, Pennsylvania

Abstract

Objectives: To discuss the potential application of intraoperative ultrasound imaging during transoral robotic surgery (TORS)

Study Design: Case series

Methods: Ultrasound imaging was performed during transoral robotic resection of oropharyngeal tumors in five patients.

Results: Intraoperative ultrasound use led to the identification of larger-caliber blood vessels within the operative field prior to encountering them visually. Ultrasound could also aid in defining the deep tumor margin. This allowed for focused, careful dissection to protect and avoid blood vessels during dissection, as well as improved tumor resection.

Conclusions: The use of intraoperative ultrasound provides additional information to the head and neck surgeon during TORS. This may be used to identify blood vessels and potentially assess tumor margins, thereby improving the safety and efficacy of TORS.

Methods

Intraoperative ultrasound was utilized during transoral robotic resection of oropharyngeal tumors in a series of patients. In each case the Aloka Alpha 7 ultrasound system (Hitachi Aloka Medical, Ltd, Wallingford, CT) with a nerve spine ultrasound probe was used. Surgical resection was performed with the DaVinci Si robotic system (Intuitive Surgical, Inc, Sunnyvale, CA). For applications in the posterior and lateral oropharynx (e.g. tonsillar fossa, parapharyngeal space), a nerve spine straight ultrasound probe was used. In order to use this ultrasound probe during TORS, the robotic arms were removed from the patient’s mouth while the camera was left in position, and the ultrasound probe was inserted alongside the camera. This provided ultrasound access to the lateral and posterior pharyngeal walls. For base of tongue imaging, a liver ultrasound probe was used. This probe is aligned at a 90 degree angle to better image the tongue base, and has a small tab on its backside that could be grasped with the Maryland dissector on the robotic arm. Thus, with this probe at least one and potentially both robotic arms could remain in the patient’s mouth along with the camera. Interspersed throughout the ultrasound images were displayed within the robotic console using the TilePro™ multi-input display (Intuitive Surgical, Inc, Sunnyvale, CA). All ultrasound imaging was performed by the surgeon.

Results

Example case

A 78 year-old female presented with a history of right-sided oropharynx carcinoma, previously treated with chemoradiation therapy. Three years later she developed a superficially invasive SCC of the left tonsil and lateral pharyngeal wall with extension to the tongue base. The patient was brought to the operating room for TORS left lateral pharyngectomy. Palpation of the carotid system could be seen along the left pharyngeal wall in the area of this lesion, and vessels could be seen deep to this tumor using the ultrasound probe (Figure 1A). Surgical dissection was performed using monopolar cautery, until the constrictor muscle was encountered (Figure 2). A hockey stick ultrasound probe was used, showing a large artery just deep to the plane of dissection (Figure 3). Further measurement with the ultrasound showed this vessel to be 1.46cm deep to current level of dissection. The vessel was safely dissected without injury in the area predicted by the ultrasound (Figure 4). At the conclusion of the dissection, large caliber vessels in the parapharyngeal space, including the carotid artery, could be clearly seen using the ultrasound within the wound bed (Figure 5). The procedure was completed uneventfully and the patient was discharged home on postoperative day one tolerating oral intake.

Figure 1: TilePro image of ultrasound use prior to starting dissection. A large blood vessel is seen in the deep lateral portion of the planned dissection (arrow).

Figure 2: Initial dissection to the level of the constrictor muscles.

Figure 3: After initial dissection, the ultrasound is used to visualize the large blood vessel near the plane of resection (arrow).

Figure 4: Careful dissection in the area identified on ultrasound leads to identification and preservation of the artery (arrow).

Figure 5: After resection of the tumor, the ultrasound again identifies several large blood vessels within the parapharyngeal space just lateral and deep to the surgical bed.

Case series

Intraoperative ultrasound was utilized in six patients undergoing TORS (Table 1). In most cases this was primarily used for identification of vascular anatomy prior and during resection; in all cases nearby vessels were seen and no vascular injuries or excessive intraoperative hemorrhage occurred. This was particularly helpful in one case of a transoral resection of a parapharyngeal space mass, where dissection was performed close to the great vessels in the parapharyngeal space. The ultrasound was also used to identify and measure the deep tumor margin in one case, which made resection clear margins easier. In one case of a patient undergoing a tongue base resection for an unknown primary tumor, the ultrasound was unable to identify the primary tumor in the lingual tonsil (patient #4). A 0.7cm primary tumor was later found on pathologic analysis of the resection specimen.

Table 1: Case Series of Intraoperative Ultrasound Use During TORS

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age/sex</th>
<th>Pathology</th>
<th>Procedure</th>
<th>Ultrasound function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>78 F</td>
<td>SCC of oropharynx, T2</td>
<td>Partial pharyngectomy</td>
<td>Vessel identification</td>
</tr>
<tr>
<td>2</td>
<td>65 M</td>
<td>SCC of base of tongue, T2</td>
<td>Base of tongue resection</td>
<td>Tumor margin assessment</td>
</tr>
<tr>
<td>3</td>
<td>60 M</td>
<td>SCC of tonsil, T2</td>
<td>Partial pharyngectomy</td>
<td>Vessel identification</td>
</tr>
<tr>
<td>4</td>
<td>83 M</td>
<td>Parapharyngeal space Warthin’s tumor</td>
<td>Transoral resection of parapharyngeal space</td>
<td>Vessel identification</td>
</tr>
<tr>
<td>5</td>
<td>71 M</td>
<td>Unknown primary</td>
<td>Tongue base resection</td>
<td>Search for unknown primary tumor</td>
</tr>
<tr>
<td>6</td>
<td>70 F</td>
<td>SCC of tonsil, T2</td>
<td>Partial pharyngectomy</td>
<td>Vessel identification</td>
</tr>
</tbody>
</table>

Discussion

Transoral robotic surgery is quickly gaining acceptance for treatment of patients with tumors of the upper aerodigestive tract. Significant bleeding intraoperatively can be quite challenging to control within the oropharynx, and postoperative hemorrhage is a potentially devastating complication. Thus any additional tools that may help the surgeon to avoid these problems would be welcomed. Current robotic surgical systems do not provide haptic feedback that may guide the surgeon during dissection. Ultrasound is widely available, easy to use, and with the use of Doppler imaging provides excellent visualization of blood vessels within tissue. Intraoperative ultrasound is widely employed in other surgical procedures, including thyroid surgery, hepatobiliary surgery60, and many other fields. With this in mind, we utilized ultrasound imaging during TORS resection of oropharyngeal lesions in several patients, to identify blood vessels and assess the deep tumor margins. In one case we were easily able to define the deep margin of a tongue base tumor, thereby providing a guide to the resection of the tumor. This ultrasound provided an accurate measurement of the tumor thickness when compared to the pathologic specimen. We were less successful in attempting to locate an unknown primary tumor within the tongue base using the ultrasound probe. This may in part be due to lack of experience with intraoperative ultrasound, or due to the relatively small size of the unknown primary tumor that was eventually found in the tongue base resection. Despite the potential advantages to using ultrasound as described above, there remain some drawbacks to its use. These include the learning curve associated with ultrasound use and the lack of a probe small enough to be mounted on the robotic arms or to be placed in the oropharynx without withdrawing the robotic arms from the patient. Nevertheless, ultrasound imaging is relatively inexpensive, widely available, and has little risk to the patient. As demonstrated here, the use of ultrasound imaging intraoperatively during TORS may provide the head and neck surgeon with the ability to anticipate the location of major blood vessels prior to visually identifying them in the surgical field, thereby reducing the risk of vascular injury. Additionally, further refinement in TORS-related ultrasound technique may allow for assessment of the interface between tumor and normal tissue, helping the surgeon to resect tumors with adequate margins. Further study of this technique has the potential to improve both the efficacy and safety of transoral robotic surgery.

Conclusions

• Intraoperative use of ultrasound imaging facilitates vessel identification and the assessment of tumor margins

• Further study and refinement of this technique may improve the safety and efficacy of TORS.

References