The Future of Robotic Thyroid Surgery and Neck Dissection

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As the preceding chapters attest, surgical robotics has moved from the realm of fantasy and science fiction to routine clinical practice. At present, the da Vinci Surgical System (Intuitive Surgical Inc., Sunnyvale, CA) is the only commercially available surgical robot. While this system is used extensively to facilitate laparoscopic minimally invasive surgery in the chest, abdomen, and pelvis, its use for surgery of the thyroid, parathyroid, and neck remains investigational. While the currently available 5- and 8-mm instruments have been appropriate for the first generation of robotic neck procedures, as technology improves, robotic systems and instruments will likely be developed whose scale and capabilities are better suited to the delicate, complex anatomy of the thyroid bed and neck.

New Robotic Systems

With robotic surgery, the surgeon and his hands are physically separate from the patient. Real surgery is performed in a virtual environment, allowing the surgeon to interact with surgical anatomy from a novel perspective, in otherwise inaccessible places and in ways that otherwise would not be possible.

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With da Vinci, a three-part robotic surgical architecture is utilized. Surgical instruments are located within a *"patient-side" cart* and are safely placed by the surgeon within the patient's body under direct and/or endoscopic guidance. A binocular 8.5- or 12-mm endoscope with dual 0° or 30° optics is used to visualize target anatomy. The three-dimensional (3-D) surgical anatomy is then recreated using the *"vision" cart,* where computer processing links the camera's image and the real-world spatial relationships of the instruments in a virtual environment. The surgeon, sitting at a *remote console cart*, can then operate within this virtual 3-D environment using "master controllers" which control and direct movements of the robotic instruments. These master controllers bear a remarkable similarity to joysticks and other handheld devices employed in video games and other virtual reality simulators. For hemostasis and energy, monopolar electrocautery and the Harmonic Scalpel® (Ethicon Endo-Surgery, Johnson & Johnson, Cincinnati, OH) are used.

Limitations of the current system include the scale of instrumentation, absence of an optimal energy source, absence of haptic feedback, and fixed angulation stereo-endoscopes. Throughout the chapters in this text, 5-mm instruments are the currently most-widely utilized for robotic neck surgery. While an improvement over 8-mm instruments, the current 5-mm instruments may still be too large for several crucial tasks, including precise and trauma-free dissection along the recurrent laryngeal nerve. The Maryland

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Dissecting Forceps have a scale resembling standard micro-Halsted dissecting forceps, though a smaller caliber, closer to the Jacobsen delicate forceps, would be preferred. Furthermore, an ideal instrument for dissection along the nerve would be fashioned with a gentle curvature that provides optimal tissue handling and traction/countertraction close to neurovascular structures. New instrumentation will likely incorporate both a smaller scale and more optimal curvature of the tip of the forceps. Although flexible at the distal end of the 5-mm instrument, the sheathed and rigid robotic arm does still limit the angle of approach to surgical anatomy. A fully flexible robotic arm throughout most of its length would allow the robotic neck surgeon to more intuitively use instruments in the thyroid bed and neck. For hemostasis, using current Intuitive Surgical instrumentation, the surgeon must choose between an 8-mm bipolar cautery Maryland Forceps and the Harmonic Scalpel (5 or 8 mm). Furthermore, in the future, a 5-mm bipolar dissecting forceps will likely be available, allowing the surgeon to manage small sites of bleeding with minimal thermal spread.

The use of the Harmonic Scalpel has been shown to be an effective surgical tool for hemostasis for thyroid and parathyroid surgery. However, ultrasonic technology requires that the surgical arm be fixed without any flexibility in the robotic arm's distal tip. This architecture may often limit the surgeon's ability to align the Harmonic Scalpel with the angle of the blood vessel or soft tissue which is being divided. Refinements in ultrasonic technology, perhaps incorporating bipolar electrocautery, may one day allow the robotic thyroid surgeon to provide better hemostasis especially along Berry's posterolateral ligament near the recurrent laryngeal nerve, without undue risk of thermal injury and the potential for either temporary or permanent neuropraxia.

Whether using remote access through either retroauricular or axillary incision, angled binocular stereo-endoscopes are a critical aspect of performing a safe robotic procedure in the neck and thyroid bed. The da Vinci provides rigid endoscopes with either 0° or 30° angulation, with an 8.5- or 12-mm diameter. The current platform offers the surgeon an unparalleled view of thyroid and neck surgical anatomy, yet in several instances, greater angulation, especially with a flexible binocular stereo-endoscope, would offer a significant clinical advantage. For instance, the use of a single ipsilateral incision to expose the anatomy of the contralateral recurrent laryngeal nerve tests the limits of the surgeon and endoscope. A variety of maneuvers described in the text provides the surgeon with a good estimation of this anatomy using the camera in the 30° down position. However, a flexible camera that would allow for 45–60° visualization would likely permit the surgeon to have better assessment of small blood vessels in the vicinity of the recurrent laryngeal nerve or alert the surgeon to unexpected patterns of branching or the presence of Zuckerkandl's tubercle.

A variety of new platforms may be coming to market in the coming years, with different configurations. These new systems will likely lead to greater integration of robotics into thyroid and parathyroid surgery.

Recommended Reading

Hockstein NG, Gourin CG, Faust RA, Terris DJ. A history of robotic surgery: from science fiction to surgical robotics. J Robot Surg. 2007;1(2):113–8.

Lee J, Chung WY. Robotic thyroidectomy and neck dissection: past, present, and future. Cancer J. 2013;19:151–61. doi:10.1097/PPO.Ob013e31828aab61.

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