Robotic endocrine surgery

Robotik endokrin cerrahi

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Özet

Gelişen teknolojiyle birlikte daha kolay kurulabilen, daha kaliteli görüntü sunan, daha küçük robotik sistemlerin kullanıma girmesi, genel cerrahinin diğer laparoskopik ameliyatlarında olduğu gibi endokrin cerrahide de robota olan ilgiyi artırmıştır. Endokrin cerrahide, çalışılan alanın darlığı, kullanılabilecek konvansiyonel alet sayısını kısıtlamaktadır. Bu nedenle endokrin cerrahi, robotik teknoloji için mükemmel bir kullanım alanıdır. Eksikliklerine ve özellikle maliyetle ilgili çekincelere rağmen robotik teknoloji, konvansiyonel aletlerin endokrin cerrahideki kısıtlamalarının üstesinden gelecek gibi görünmektedir. Bu derlemede, robotik transaksiller tiroidektomi ve paratiroidektomi, robotik posterior retroperitoneal ve lateral transabdominal adrenalektomi teknikleri anlatılmakta ve bu yeni teknolojinin endokrin cerrahiye getirileri literatür ışığında gözden geçirilmektedir.

Anahtar sözcükler: endokrin cerrahi, robotik cerrahi

Abstract

With the refinement of the technology, easier set up, better image quality, and smaller robotic systems, there has been an interest in using the robot for general surgical laparoscopic procedures as well as for endocrine surgery. Endocrine surgery procedures are excellent targets for robotic instrumentation as the conventional endoscopic techniques require working in a small space, significantly limiting the type of equipment that can be used. Although robotic technology has some deficiencies and as yet unanswered questions especially about its cost effectiveness, this technology seems to be successful in overcoming the limitations of conventional laparoscopic technology in endocrine surgery. This article describes the techniques of robotic transaxillary thyroidectomy, parathyroidectomy and both lateral transabdominal and posterior retroperitoneal adrenalectomy and reviews the literature regarding the periprocedural outcomes of this new technology in endocrine surgery.

Keywords: endocrine surgery, robotic surgery

Minimal invasive endocrine surgery encompasses surgical procedures on the endocrine glands, including the adrenals, thyroid and parathyroids. The first report of laparoscopic endocrine surgery belongs to Gagner et al in 1992, with their publication on laparoscopic adrenalectomies[1]. Since then, numerous publications describing new techniques and experiences about laparoscopic adrenal, thyroid and parathyroid surgery have appeared in the literature[2-5]. At present, standard laparoscopic instruments still have some limitations including instrument maneuverability in small spaces like the neck and the retroperitoneum, spaces where some endocrine organs are located.

Robotic technology, introduced only in the last decade, has gained popularity in all fields of general surgery as well as in endocrine surgery. The robotic technology provides improved dexterity owing to the seven degrees of freedom and angulation at the tip of the instruments, mimicking the human hand. It seems to deal with most of the limitations of laparoscopy such as fixed axis points at the trocar insertion sites and two dimensional image without depth perception. With this technology, it is possible to perform precise dissection and suturing in small cavities and also undertake more complicated procedures through small incisions.

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Table 1: Robotic adrenalectomies

Author	Year	Tumor size (cm)	BMI	Number of patients	Operation time (min)	Length of stay (day)
Berber	2010	2.9		8	215	1
Brunaud	2008	2.8	27	50	104	6.3
Krane	2008			4	76	1
Wu	2008	5.1	24	5	188	4
Winter	2006	-	26	30	185	2
Morino	2004	3.3	22	10	169	5.7
Beninca	2003	-	-	9	133	5.7
Bentas	2002	3.8		4	220	5
Young	2002	-	-	1	100	1
Desai	2002	3.8	24	2	138	2.5
Horgan	2001	-	-	1	-	2
Piazza	1999	3	-	1	180	2

The current robotic systems include the da Vinci Robotic Surgical System (Intuitive Surgical, Mountain View, California). The da Vinci system consists of a surgeon console and a surgical arm cart. The arm cart holds the endoscopic camera and the instruments. The endoscope is a 12 mm, specially designed dual camera that sends three dimensional images to the screen in the console called the InSite Vision System. The system eliminates all peripheral images and enables the surgeon to focus on the operative field. The camera and instruments are controlled by maneuvering the joysticks on the console. The instrument tip has the same flexible movements of a human hand. The surgeon inserts his fingers into the handles, sits in an ergonomic position and maneuvers the instruments with up to seven degrees freedom. In addition, robots reduce the natural tremor of the human hand. An assistant can be positioned near the manipulator unit to either retract or provide suction as needed.

Adrenalectomy

Since the first laparoscopic transabdominal adrenalectomy was performed in 1992 by Gagner et al., more reports have documented the feasibility of transperitoneal or extraperitoneal laparoscopic adrenalectomy[1-3, 6]. The main advantages of laparoscopic adrenalectomy over the routine open adrenalectomy include shorter intervention time for unilateral adrenalectomies and less postoperative pain, fewer perioperative and postoperative complications, and shorter period of hospitalization[6,7]. On the other hand, the laparoscopic adrenalectomy lacks 3D visualization, restricts the degrees of freedom of movement, and has the potential for inaccuracy during the delicate dissection of the adrenal parenchyma, veins, and arteries. The initial robotic-assisted adrenalectomy report was published in 1999 by Piazza et al from Italy[8]. In the early 2000s some other groups published their results on robotic adrenalectomy via the transabdominal route[9-12]. Horgan and Vanuno reported the use of the da Vinci in a bilateral adrenalectomy[13]. They reported that the da Vinci System provided superior articulation that greatly improved the precision and efficacy of the lateral and posterior dissection of the adrenal gland.

We published the first report describing robotic posterior retroperitoneal (PR) adrenalectomy in 2010[14]. We have demonstrated the feasibility and safety of robotic PR adrenalectomy in an initial series of 8 patients. Robotic PR adrenalectomy is different from other robotic abdominal procedures because the ports are placed closer than usual to each other. This requires the robotic procedure to be performed with minimal errors. Owing to the proximity of the ports to each other, the robotic docking process is more tedious as compared to transabdominal lateral adrenalectomy. The placement of the working ports as far as possible from the camera port is important to the procedure. The ports are placed in the same manner as in laparoscopic cases. A fourth trocar is used for the first assistant for the transabdominal cases **(Table 1), (Fig. 1, 2)**.

We use ultrasonography (USG) both in lateral transabdominal and posterior retroperitoneal approaches. The initial percutaneous and subsequent laparoscopic USG findings are helpful in guiding the placement of ports and dissection of the adrenal gland. We found dissection to be easier with the robotic approach compared with the conventional laparoscopic approach. This is owing to the seven degrees of freedom with the robotic instruments. Although the mean operating time in this series is longer than that reported in our laparoscopic posterior adrenalectomy cases, this might be due to

Fig. 1. Robotic posterior retroperitoneal adrenalectomy, port placement

Fig. 2. Robotic lateral transabdominal adrenalectomy, port placement

both our learning curve and, because of the advantages of robotic instrumentation, to selection of more complicated cases for the posterior approach[6]. Robotic PR adrenalectomy is feasible. The use of the robot facilitates the procedure by overcoming the current limitations of the laparoscopic technique.

Thyroidectomy

Since the establishment of the techniques for safe and efficient thyroid surgery in 1920[15] there have been minor changes in the procedure. The major refinement has been the incorporation of the vessel sealing and cutting instruments instead of knot tying to shorten operative time[16]. More recently, in search for better cosmetic results, there have been attempts to apply minimally invasive techniques in thyroid surgery. In 1996, Gagner and colleagues published the first few cases of endoscopic parathyroidectomy in humans, initiating endoscopic neck surgery for endocrine pathology[4]. Since the first report, various techniques for minimally invasive thyroid surgery have been described[5,17,18]. Robotic surgical technology was developed to overcome the limitations of laparoscopic instruments. Kang and colleagues from South Korea reported their experience in 100 patients with papillary thyroid carcinoma who underwent robot-assisted endoscopic thyroidectomy using a gasless transaxillary approach[19]. This team has performed 84 subtotal and 16 total thyroidectomies with ipsilateral central neck dissection within a mean operation time of 136.5 minutes. The mean console time was 60 minutes. No serious complications were encountered during the procedure. The authors have concluded that the technique is a feasible, safe and effective method for selected patients with thyroid cancer. Lee et al reported 15 patients with papillary thyroid cancer in whom the operation was performed using the bilateral axillary breast approach[20]. Their mean operating time was 218 minutes. Recurrent laryngeal nerve and parathyroids were identified in detail in all patients and no perioperative complications were encountered. In the same year Kang et al reported another series of 338 cases with thyroid tumor treated by robotic assisted thyroidectomy[21]. Mean operative time was 144 ± 43.5 minutes. The mean time spent to create a working space was 29.1± 13.9 minutes. Mean docking time was 6.4 ± 4.6 minutes, and mean console time was 59.1 ± 25.7 minutes. 234 patients underwent subtotal and 104 bilateral total thyroidectomy. Central neck dissection was performed in all malignant cases. No case was converted to conventional laparoscopic or open procedure. Mean tumor diameter was 0.8±0.5 cm. There were 332 cancers and 6 benign cases in the series. The mean number of lymph nodes retrieved per patient was 5 ± 3.7. Mean hospital stay was 3.3 ± 0.8 days.

We have reported our first 2 robotic thyroidectomies **(Fig. 3-5)** in 2010[22]. Both patients had thyroid cancer. There were no perioperative complications and both patients were discharged on the 1st postoperative day. Tae et al reported 41 patients who underwent robotic assisted thyroidectomy. Their experience was a longer operative time, but greater cosmetic satisfaction compared to conventional open surgery and a similar complication rate[23]. Most recently, a multicentric experience of robotic thyroidectomy from Korea involving 1043 thyroid carcinoma patients has been reported[24]. Of these patients 366 has undergone total, and 677 subtotal thyroidectomies with cervical lymph node dissection. The mean operation time, and console time were 132 and 63.9 minutes, respectively. There were postoperative major morbidities in 10 patients (1%). The mean tumor size was 0.8 cm and mean number of retrieved lymph nodes per patient was 5.1.

Parathyroidectomy

Profanter et al reported the first case of robot assisted thoracoscopic resection of a mediastinal parathyroid ade-

Fig. 3. Upper pole dissection in robotic transaxillary thyroidectomy

Fig. 4. Robotic transaxillary bilateral total thyroidectomy

noma in the aortopulmonary window in 2004[25]. Subsequently, Brauman et al reported 5 patients who underwent robotic assisted thoracoscopic mediastinal parathyroidectomy with no perioperative complications, with median operating and docking times of 58 and 9 minutes, respectively[26]. The median hospital stay was 5 days. There are also several case reports of successful robotic assisted thoracoscopic parathyroidectomies[27,28]. We have also performed 3 robotic parathyroidectomies **(Fig. 6)**, including a mediastinal parathyroidectomy. The port placement for transaxillary robotic parathyroidectomy is the same as that applied for the robotic thyroidectomy procedure.

Conclusion

With the refinement of the technology, easier set up, better image quality, and smaller robotic systems, there has been a renewed interest in using the robot for general surgical laparoscopic procedures as well as endocrine surgery. The learning curve is shorter compared with laparoscopy and extensive laparoscopic experience is not mandatory to become proficient in robotic surgery. The visualization system combines the benefit of a three-dimensional operating field with the ability to magnify small structures and the ergonomic design of the console reduces fatigue of the surgeon in time consuming interventions. Endocrine surgery procedures are excellent targets for robotic instrumentation as the conventional endoscopic techniques require working in a small space, significantly limiting the type of equipment that can be used. As the thyroid and parathyroids are located in a cosmetically sensitive area of the body, alternative surgical techniques which avoid a neck incision may be attractive for patients. Minimal invasive parathyroidectomy excludes the need for sternotomy or thoracotomy in situations where it is not possible to reach the ectopic mediastinal parathyroid from the neck incision. In our cases excellent visualization of the vital structures was possible both in adrenal and thyroid cases. Nevertheless, there are some issues that need to be discussed for robotic thyroid surgery. First of all, although no incision is made on the neck, the area of dissection is larger compared with conventional thyroidectomy. So, in fact it is not a minimal invasive procedure. It is our opinion that thin, relatively short patients with small nodules should be given preferance in the initial selection criteria. In the Korean experience the robotic transaxillary total thyroidectomy offered equivalent oncologic outcomes to conventional open surgery, and showed that it is safe for use in known or suspected thyroid cancer[19]. The final pathology turned out to be malignant in both of our cases. We believe that we accomplished the same oncologic resection as in an open thyroidectomy, and that there was no compromise of oncologic principles. Robotic surgery also has several limitations. For example, the system is almost completely lacking in tactile feedback, the selection of robotic instruments is limited, the tip of the ultrasonic dissectors do not have the ability of angulation. Placement of additional ports is generally needed especially for suction, because at present a robot applicable suction device is not available. The system requires the presence of an onsite surgical assistant and the assistant does not have the same visualization facilities as the surgeon on the console. Currently the robotic system has a higher cost than conventional procedures.

Despite its deficiencies, robotic technology seems to succeed in overcoming the limitations of conventional laparoscopic technology. Endocrine surgery, due to the anatomic localizations of the endocrine organs, is an ideal target for robotic surgery.

References

1. Gagner M, Lacroix A, Bolte E. Laparoscopic adrenalectomy in cushing's syndrome and pheochromocytoma. N Engl J Med 1992;327:1033.

Fig. 5. Appearance of scars two weeks after robotic transaxillary thyroidectomy

Fig. 6. Parathyroid gland dissection in robotic transaxillary parathyroidectomy

2. Mercan S, Seven R, Ozarmagan S, Tezelman S. Endoscopic retroperitoneal adrenalectomy. Surgery 1995;118:1075-1076.
3. Siperstein AE, Berber E, Engle KL, Duh QY, Clark OH. Laparoscopic posterior adrenalectomy: Technical considerations. Arch Surg 2000;135:967-971.
4. Gagner M. Endoscopic subtotal parathyroidectomy in patients with primary hyperparathyroidism. Br J Surg. 1996;83:875.
5. Huscher CS, Chiodini S, Napolitano C, Recher A. Endoscopic right thyroid lobectomy. Surg Endosc 1997;11:877.
6. Berber E, Tellioglu G, Harvey A, Mitchell J, Milas M, Siperstein A. Comparison of laparoscopic transabdominal lateral versus posterior retroperitoneal adrenalectomy. Surgery 2009;146:621-625.
7. Hansen P, Bax T, Swanstrom L. Laparoscopic adrenalectomy: History, indications, and current techniques for a minimally invasive approach to adrenal pathology. Endoscopy 1997;29:309-314.
8. Piazza L, Caragliano P, Scardilli M, Sgroi AV, Marino G, Giannone G. Laparoscopic robot-assisted right adrenalectomy and left ovariectomy (case reports). Chir Ital 1999;51:465-466.
9. Bentas W, Wolfram M, Brautigam R, Binder J. Laparoscopic transperitoneal adrenalectomy using a remote-controlled robotic surgical system. J Endourol 2002;16:373-376.
10. Desai MM, Gill IS, Kaouk JH, Matin SF, Sung GT, Bravo EL. Robotic-assisted laparoscopic adrenalectomy. Urology 2002;60:1104-1107.
11. Morino M, Beninca G, Giraudo G, Del Genio GM, Rebecchi F, Garrone C. Robot-assisted vs laparoscopic adrenalectomy: A prospective randomized controlled trial. Surg Endosc 2004;18:1742-1746.
12. Brunaud L, Bresler L, Zarnegar R, Ayav A, Cormier L, Tretou S, et al. Does robotic adrenalectomy improve patient quality of life when compared to laparoscopic adrenalectomy? World J Surg 2004;28:1180-1185.
13. Horgan S, Vanuno D. Robots in laparoscopic surgery. J Laparoendosc Adv Surg Tech A 2001;11:415-419.
14. Berber E, Mitchell J, Milas M, Siperstein A. Robotic posterior retroperitoneal adrenalectomy: Operative technique. Arch Surg 2010;145:781-784.
15. Becker WF. Presidential address: Pioneers in thyroid surgery. Ann Surg 1977;185:493-504.
16. Siperstein AE, Berber E, Morkoyun E. The use of the harmonic scalpel vs conventional knot tying for vessel ligation in thyroid surgery. Arch Surg 2002;137:137-142.
17. Lombardi CP, Raffaelli M, de Crea C, Princi P, Castaldi P, Spaventa A, et al. Report on 8 years of experience with video-assisted thyroidectomy for papillary thyroid carcinoma. Surgery 2007;142:944-951.
18. Chung YS, Choe JH, Kang KH, Kim SW, Chung KW, Park KS, et al. Endoscopic thyroidectomy for thyroid malignancies: Comparison with conventional open thyroidectomy. World J Surg 2007;31:2302-2307.
19. Kang SW, Jeong JJ, Yun JS, Sung TY, Lee SC, Lee YS, et al. Robot-assisted endoscopic surgery for thyroid cancer: Experience with the first 100 patients. Surg Endosc 2009;23:2399-2406.
20. Lee KE, Rao J, Youn YK. Endoscopic thyroidectomy with the da vinci robot system using the bilateral axillary breast approach (BABA) technique: Our initial experience. Surg Laparosc Endosc Percutan Tech 2009;19:71-75.
21. Kang SW, Lee SC, Lee SH, et al. Robotic thyroid surgery using a gasless, transaxillary approach and the da vinci system: The operative outcomes of 338 consecutive patients. Surgery 2009;146:1048-1055.
22. Berber E, Heiden K, Akyildiz H, Milas M, Mitchell J, Siperstein A. Robotic transaxillary thyroidectomy: Report of 2 cases and description of the technique. Surg Laparosc Endosc Percutan Tech 2010;20:60-63.
23. Tae K, Ji YB, Jeong JH, Lee SH, Jeong MA, Park CW. Robotic thyroidectomy by a gasless unilateral axillo-breast or axillary approach: Our early experiences. Surg Endosc 2010 Jun 22. [Epub ahead of print] PMID: 20567849
24. Lee J, Yun JH, Nam KH, Choi UJ, Chung WY, Soh EY. Perioperative clinical outcomes after robotic thyroidectomy for thyroid carcinoma: A multicenter study. Surg Endosc 2010 Aug 24. PMID: 20734075
25. Profanter C, Schmid T, Prommegger R, Bale R, Sauper T, Bodner J. Robot-assisted mediastinal parathyroidectomy. Surg Endosc 2004;18:868-870.
26. Braumann C, Jacobi CA, Menenakos C, Ismail M, Rueckert JC, Mueller JM. Robotic-assisted laparoscopic and thoracoscopic surgery with the da vinci system: A 4-year experience in a single institution. Surg Laparosc Endosc Percutan Tech 2008;18:260-266.
27. Brunaud L, Ayav A, Bresler L, Schjott B. Da vinci robot-assisted thoracoscopy for primary hyperparathyroidism: A new application in endocrine surgery. J Chir (Paris) 2008;145:165-67.
28. Chan AP, Wan IY, Wong RH, Hsin MK, Underwood MJ. Robot-assisted excision of ectopic mediastinal parathyroid adenoma. Asian Cardiovasc Thorac Ann 2010;18:65-67.