

# Robot-assisted complete thymectomy for mediastinal ectopic parathyroid adenomas in primary hyperparathyroidism

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**Abstract** One to two percent of ectopic parathyroid adenomas are found in the lower mediastinum and often these are best accessed via a sternotomy or thoracotomy. Video-assisted thoracoscopic surgery (VATS) is an alternative approach with less surgical trauma, decreased morbidity, shorter hospital stays, and superior cosmetic results. Ten years after the first VATS resection of an ectopic mediastinal parathyroid, a robot-assisted thoracoscopic approach was described. Here we describe a series of five robot assisted complete thymectomies in patients with primary hyperparathyroidism due to mediastinal ectopic parathyroid adenomas. A single surgeon, single institution case series of five consecutive robotic-assisted mediastinal parathyroidectomies was performed between March 2013 and September 2015. The patients' ages ranged from 31 to 65, 80 % were female, and all had primary hyperparathyroidism due to an ectopic parathyroid located in the lower mediastinum. Pre-operative imaging workup included Technetium 99-sestimi parathyroid scan and CT scan of the chest. An ectopic parathyroid adenoma was successfully removed in all five cases, with intraoperative iOPTh decreasing ~50 % from baseline after 10 minutes. A hypercellular parathyroid was confirmed on pathologic exam in all specimens. Post-operative discharge and follow up calcium levels all returned to normal. There were no intraoperative complications, including no recurrent

laryngeal nerve injuries, no postoperative morbidity, and no mortalities. This case series demonstrates that a robot-assisted complete thymectomy for mediastinal parathyroid adenomas causing primary hyperparathyroidism provides excellent visualization of the mediastinum, is effective at reducing PTH and calcium levels, and is safe with no morbidity or mortality.

**Keywords** Mediastinal tumor · Mediastinum · Thymectomy · Robotics

## Introduction

Parathyroid adenomas are found in ectopic locations in up to 15–20 % of patients and 1–2 % are located in the lower mediastinum [1]. This location poses a technical challenge to the endocrine surgeon, as deep mediastinal parathyroids are often not accessible using a cervical approach and a sternotomy or thoracotomy is required. These approaches, although standard [2, 3], have been challenged by newer, more minimally invasive approaches. Video-assisted thoracoscopic surgery (VATS) was first introduced in 1992 and has gained acceptance as an alternative approach with less surgical trauma, decreased morbidity, shorter hospital stays, and superior cosmetic results [4–6]. The first VATS resection of an ectopic mediastinal parathyroid was performed by Prinz in 1994 [7]. Ten years later Profanter et al., performed the first robot-assisted thoracoscopic resection of an ectopic mediastinal parathyroid adenoma [8]. The three-dimensional view, articulated instruments with 360-degree rotation, 7° of freedom, and tremor filtering associated with robotic instrumentation has made it a promising alternative approach when applied to the mediastinum [9]. Several limited case reports have described

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robotic-assisted mediastinal parathyroidectomy for hyperparathyroidism [9–20]. In all five of our cases, we performed a thymectomy, resecting the ectopic parathyroid with the thymus en bloc, which avoids parathyroid capsule rupture and results in an appropriate drop in intraoperative parathyroid hormone levels.

## Methods

A single surgeon, single institution case series of 5 consecutive robotic-assisted mediastinal parathyroidectomies was performed between March 2013 and September 2015. Three patients underwent cervical parathyroid explorations prior to robotic resection: two of which had subtotal parathyroidectomy for parathyroid hyperplasia and one had four normal parathyroids identified, all with inadequate drop in intraoperative PTH (iOPTH). The other two patients had a single mediastinal parathyroid identified on preoperative imaging without prior cervical exploration. The patients' ages ranged from 31 to 65, 80 % were female, and all had primary hyperparathyroidism due to an ectopic parathyroid located in the lower mediastinum (Table 1). Pre-operative imaging workup included Technetium 99-sestamibi parathyroid and CT scan of the chest (Fig. 1). Preoperative calcium levels ranged from 10.1 to 11.1. The first four patients underwent robotic-assisted mediastinal parathyroidectomy using the DaVinci Si and the last patient with the DaVinci Xi robot (Intuitive Surgical Inc., Sunnyvale, CA).

## Procedure details

Peripheral venous access was obtained and a radial arterial line was placed contralateral to the side on which the dissection was performed. The patient was intubated with a double lumen endotracheal tube and position was confirmed with bronchoscopy. A foley catheter was placed and

DVT prophylaxis was provided with sequential compression boots. A baseline iOPTH level was drawn off of the arterial line.

Patient positioning depended upon the location of the adenoma on preoperative imaging studies. Patients with an adenoma at the level of the ascending aorta and to the right were positioned in a supine position with a chest bump and approached from the right. Patients with an adenoma to the left of the ascending aorta or in the aorto-pulmonary window were positioned in the lateral decubitus position, which facilitated the robotic approach by shifting the mediastinum to the right, and creating more space in the left chest. Axillary and flank rolls were used and the table was flexed. An alternative would be a supine left-sided approach, but we feel the decubitus position simplifies the robotic procedure.

The patient was prepped in standard sterile fashion and single lung ventilation was initiated. For the right-sided supine approach, three 8 mm robotic ports were placed in the 2nd, 4th, and 6th interspaces in a V-shape configuration (Fig. 2). For the left sided approach the ports were placed in a V configuration in the 4th, 6th, and 7th interspaces. The assistant port was placed lower down in the 9th interspace (Fig. 3). The robotic camera was placed first, CO<sub>2</sub> insufflation was initiated, followed by placement of the left and right arms. The robotic arms were then connected and docked and the mediastinal dissection was carried out. Despite good localization of mediastinal parathyroids on preoperative imaging, it was often difficult to identify 1 cm or smaller ectopic adenomas intraoperatively. As a result we elected to perform complete mediastinal thymectomy, incorporating the ectopic parathyroid en bloc. The phrenic nerves were seen and spared, and for left sided approaches the recurrent laryngeal nerve was identified and preserved. The thymic veins were ligated with hemo-occlusive clips and all mediastinal tissue, including thymus, fibrofatty tissue, as well as the mediastinal fat pad up to the aortopulmonary window (for left

**Table 1** Patient demographics

Patient	Pre-op diagnosis	Age	Sex	Prior neck exploration	# Of parathyroids, prior pathology	Pre-op imaging
1	Primary hyperparathyroidism	31	M	No	X	Sestamibi parathyroid scan CT chest
2	Primary hyperparathyroidism	39	F	Yes	4 Biopsies, all normal parathyroid tissue	Sestamibi parathyroid scan CT chest
3	Primary hyperparathyroidism	55	F	Yes	3.5 Removed, all hypercellular parathyroid glands	Sestamibi parathyroid scan CT neck/chest
4	Primary hyperparathyroidism	65	F	Yes	3.5 Removed- all hypercellular parathyroid glands	Sestamibi parathyroid scan CT chest
5	Primary hyperparathyroidism	61	F	No	X	Sestamibi parathyroid scan CT neck/chest

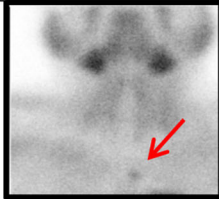
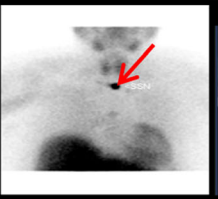

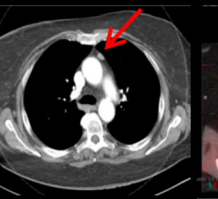
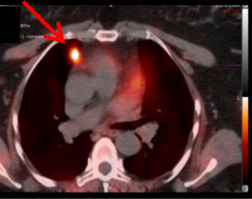
Patient #	1	2	3	4	5
Image Modality	Sestamibi Scan	Sestamibi Scan	Sestamibi Scan	CT Chest	Sestamibi Scan
					

Fig. 1 Pre-operative Imaging



Fig. 2 Right sided approach

sided adenomas) was removed using a specimen bag (Fig. 4). Once the mediastinal dissection and thymectomy were complete, an iOPTh level was obtained, confirming that the level dropped by at least 50 % and into the normal range [21]. Hemostasis was achieved and a Blake drain or chest tube was placed in the anterior mediastinum. The robotic arms were removed and the lung was re-expanded. The ports were then removed and the port sites were closed in layers.

**Results**

An ectopic parathyroid adenoma was successfully removed in all five cases, with intraoperative iOPTh decreasing ~50 % from baseline after 10 minutes. A hypercellular parathyroid was confirmed on pathologic exam in all specimens. Post-operative discharge calcium levels all returned to normal. Follow up calcium levels as an outpatient remained normal (Table 2). There were no intraoperative complications, including no recurrent laryngeal nerve injuries, no postoperative morbidity, and no mortalities. Estimated blood loss ranged from 25 to 100 cc. All patients were extubated in the OR. The average length of



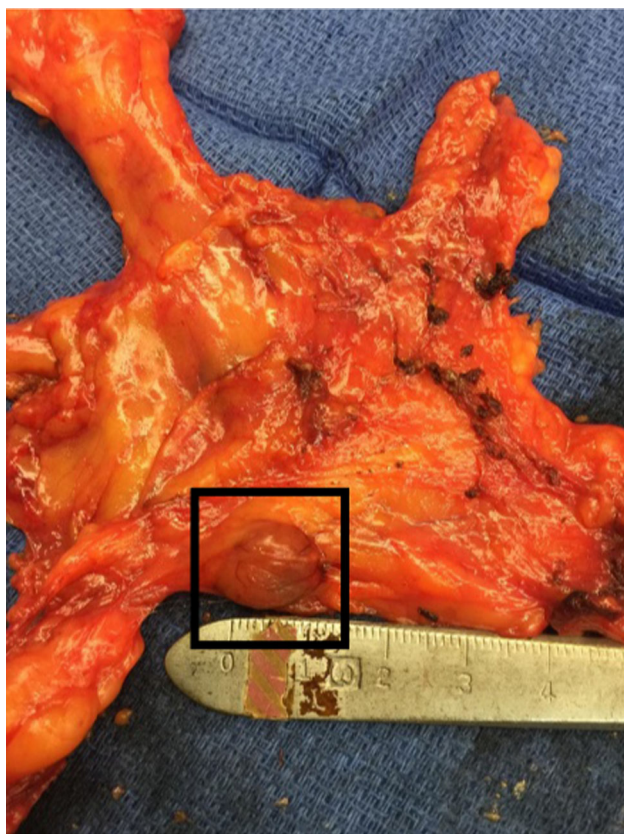
Fig. 3 Lateral decubitus, left sided approach

stay was 1.4 days, and the mediastinal drain was removed on post-operative day 1 in all cases.

**Comment**

Ectopic mediastinal parathyroid adenomas can pose a challenge to the endocrine surgeon. Here, we demonstrate that robotic-assisted mediastinal parathyroidectomy is safe and effective in resecting the ectopic parathyroid gland and ultimately in treating the patient’s primary hyperparathyroidism. We recommend a full pre-operative work-up including parathyroid gland localization with cervical





**Fig. 4** Mediastinal fat specimen with ectopic parathyroid adenoma

ultrasound and Sestamibi scan followed by chest CT to better delineate the surrounding anatomy. Harvey et al. recommend a Sestamibi/iodine subtraction SPECT/CT scan with intravenous contrast, which provides a fused functional–anatomic image [15]. Four-dimensional CT with contrast has shown superior specificity compared with functional imaging alone [17]. Preoperative laryngoscopy should be performed for patients who have had prior neck operations to rule out recurrent laryngeal nerve injury. Cryopreservation should be considered in patients who have had prior cervical parathyroidectomy for multiple gland disease.

A VATS approach to mediastinal tumors provides several advantages over open approaches. As compared to the standard sternotomy or thoracotomy, postoperative pain and length of stay are significantly reduced and there is improved cosmesis after thoracoscopy [4–6]. The use of VATS over the past two decades has addressed the drawbacks of open surgery but visualization of the mediastinum can be suboptimal and degrees of freedom are limited during dissection in a field containing critical structures. Robotic-assisted mediastinal surgery has developed significantly over the past 15 years [22]. In 2004, Profanter et al. described the first case of robot-assisted thoracoscopic resection of a mediastinal parathyroid adenoma in the aorto-

**Table 2** PTH and calcium levels pre- and post-operatively

Patient #	Pre-op iPTH	Pre-op calcium	Baseline iOPTH	10 min post-excision iOPTH	% iOPTH decrease from baseline	Post-op calcium	Length of stay (days)	Post-discharge calcium (days post-op)	Pathology	Gland size
1	118.1	10.7	140.1	18.91	87	8	1	10.7 (111)	Hypercellular parathyroid gland	1 cm greatest dimension
2	107.1	10.1	94.9	19.2	80	8.7	1	10 (17)	Hypercellular parathyroid gland	0.9 × 0.7 × 0.5 cm
3	104	10.1	117.4	62.05	47	8.4	3	9.4 (55)	Hypercellular parathyroid gland	0.6 cm greatest dimension
4	227	11.1	210.1	24.8	88	9	1	9.1 (61)	Hypercellular parathyroid gland	1.0 × 1.0 × 1.0 cm
5	68	11.1	121.7	45.5	63	8.7	1	8.7 (1)	Hypercellular parathyroid gland	1.2 cm × 0.8 cm × 0.8 cm

**Table 3** Robotic mediastinal parathyroid resection cases

Authors	Title	Year	# Of cases	Mediastinal pathology	Excision of adenoma or thymectomy for parathyroid?	Complications	Chest tube removal (days post-op)	Length of stay (days)
Bodner et al. [11]	Mediastinal parathyroidectomy with the da vinci robot: presentation of a new technique	2004	1	<b>Parathyroid adenoma in aorto-pulmonary window</b>	Excision of parathyroid adenoma	Hoarseness from L recurrent laryngeal nerve injury	2	4
Bodner et al. [12]	Early experience with robot-assisted surgery for mediastinal masses	2004	14	9 Thymectomies, 3 paravertebral neuromas, <b>1 mediastinal parathyroidectomy</b> , 1 lymphangioma	Excision of parathyroid adenoma	1 Conversion to open because tumor size limited vision, 1 hoarseness from L recurrent laryngeal nerve injury	2	X
Bodner et al. [23]	First experiences with the da vinci operating robot in thoracic surgery	2004	36	10 Thymectomies, 16 funduplications, 4 esophageal dissections, 5 benign mediastinal masses (3 paravertebral tumors, 1 mediastinal mass, <b>1 ectopic parathyroid</b> ), 1 lobectomy	Excision of parathyroid adenoma	1 Conversion to open, 1 hoarseness from L recurrent laryngeal nerve injury	2	6 (3–8)
Profanter et al. [8]	Robot-assisted mediastinal parathyroidectomy	2004	1	<b>Parathyroid Adenoma in aorto-pulmonary window</b>	Excision of parathyroid adenoma	None	X	4
Augustin et al. [10]	The robotic approach for mediastinal lesions	2006	33	22 Thymectomies, 4 paravertebral neuromas, <b>1 mediastinal parathyroidectomy</b> , 1 lymphangioma, 1 ectopic goiter, 1 lymph node metastasis, 3 esophageal procedures	Excision of parathyroid adenoma	Three conversions to open. 1 transient L recurrent laryngeal nerve palsy	X	X
Tanna et al. [18]	Da vinci robot-assisted endocrine surgery: novel applications in otolaryngology	2006	2	<b>1 Mediastinal parathyroid</b> , 1 goiter with mediastinal extension	Thymectomy	None	X	5
Brunaud et al. [13]	Da vinci robot-assisted thoracoscopy for primary hyperparathyroidism: a new application in endocrine surgery	2008	1	<b>Parathyroid Adenoma in aorto-pulmonary window</b>	Excision of parathyroid adenoma	None	X	X
Timmerman et al. [19]	Hyperparathyroidism: robotic-assisted thoracoscopic resection of a supernumerary anterior mediastinal parathyroid tumor	2008	1	<b>Parathyroid Adenoma in anterior mediastinum</b>	Excision of parathyroid adenoma	None	X	<72 h
Chan et al. [14]	Robot-assisted excision of ectopic mediastinal parathyroid adenoma	2010	1	<b>Parathyroid Adenoma</b> in right paratracheal space at sternal notch level	Excision of parathyroid adenoma	None	1	3

**Table 3** continued

Authors	Title	Year	# Of cases	Mediastinal pathology	Excision of adenoma or thymectomy for parathyroid?	Complications	Chest tube removal (days post-op)	Length of stay (days)
Ismail et al. [16]	Resection of ectopic mediastinal parathyroid glands with the da vinci robotic system	2010	5	<b>Mediastinal parathyroid glands</b> (2 secondary recurrent hyperparathyroidism, 3 primary hyperparathyroidism)	Excision of parathyroid adenoma	None	1–2	3 (2–4)
Yadav et al. [20]	Case of the season: ectopic parathyroid adenoma in the pericardium: a report of robotically assisted minimally invasive parathyroidectomy	2010	1	<b>Parathyroid Adenoma in Anterior Pericardium</b>	Excision of parathyroid adenoma	None	X	X
Harvey et al. [15]	Robotic thoracoscopic mediastinal parathyroidectomy for persistent hyperparathyroidism: case report and review of the literature	2011	1	<b>Parathyroid adenoma in mediastinum</b>	Thymectomy	None	X	2
Rea et al. [9]	Single-institution experience on robot-assisted thoracoscopic operations for mediastinal diseases	2011	108	100 Thymectomies, 3 paravertebral tumors, 1 thymic cyst, 1 ectopic goiter, <b>1 mediastinal parathyroidectomy</b> , 1 thymic carcinoid, 1 foregut cyst	Excision of parathyroid adenoma	Three cases required 4th access site; 2 hemothorax, 1 chylothorax, 1 fever	1	3 (2–14)
Van Dessel et al. [25]	Mediastinal parathyroidectomy with the da vinci robot	2011	2	<b>2 Parathyroid adenomas in mediastinum</b>	Thymectomy	None	2	3
Karagkounis et al. [26]	Robotic surgery for primary hyperparathyroidism	2014	14	<b>Parathyroid adenomas</b> —8 cervical, <b>6 mediastinal</b>	Thymectomy	1 Pericardial and bilateral pleural effusions due to Dressler's Syndrome	X	2.2

Mediastinal parathyroid resections within each series are bolded

pulmonary window. There were no complications and the patient was discharged home 4 days later [8]. That same year Bodner et al. described 14 patients with robotically resected mediastinal masses resected using the daVinci robot; 1 of these was an ectopic parathyroid [11, 12, 23]. They found dissecting within the narrow aorto-pulmonary window to be more accurate and safe with the robot than with conventional VATS, and the 3-D optics made it easier to locate the tumor [24]. Between 2001 and 2005, Augustin et al. performed 33 mediastinal mass excisions (including 1 ectopic parathyroid) using the daVinci robot. There were no surgical mortalities and no major surgical complications in any of the patients; three cases were converted to open. One transient left laryngeal recurrent nerve palsy was observed after resection of a tumor from the aorto-pulmonary window

[10]. Between 2002 and 2010, Rea et al. performed 108 robotic-assisted mediastinal resections (including 1 ectopic parathyroid). There were no conversions to open but three cases required placement of an additional port. Similar to our experience, all patients were extubated in the OR and the median time to mediastinal drain removal was 1 day [9]. Van Dessel et al. performed 2 robotic mediastinal parathyroid resections in 2011, preferring the use of the robot for mediastinal dissection because of its 3D view, stable camera platform, and fine dissection with wrist-free mobility to make the mediastinum more accessible [25]. In 2014 Karagkounis described six cases of robotic-assisted resection of ectopic mediastinal parathyroid adenomas for primary hyperparathyroidism. Length of stay after the transthoracic approach was 2.2 days and one patient developed pericardial

and bilateral pleural effusions [26]. Multiple, mostly single case reports of robotic resection for mediastinal parathyroidectomy describe similar benefits of improved visualization and shorter recovery [13, 14, 18–20] (Table 3).

This case series of robot-assisted complete thymectomy for mediastinal parathyroids causing primary hyperparathyroidism demonstrated that the procedure provided excellent visualization of the mediastinum, was effective at reducing PTH levels in all cases, was safe with no morbidity or mortality, and less than 2 day lengths of stay. With a total resection of mediastinal fat and thymus, the culprit parathyroid is removed safely en bloc, without capsular rupture or lengthy dissection. Close coordination with an endocrine surgeon is essential and appropriate preoperative imaging studies are critical to assist with preoperative planning.

#### Compliance with ethical standards

**Conflict of interest** There are no conflicts of interest.

**Funding** There were no sources of funding.

**Ethical approval** This research did not involve animals.

**Informed consent** Informed consent was obtained prior to surgery and all patient data was de-identified.

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