Different methods for surgical treatment of ectopic parathyroid in the mediastinum

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Background Ectopic parat hyroid glands result from aberrant migration during early stages of development. They constitute a common etiology of persistent or recurrent hyperparathyroidism when they are missed at initial diagnosis. Ectopic inferior parathyroid glands are most frequently found in the anterior mediastinum, in association with the thymus or the thyroid gland.

Patients and methods and results Eight cases of ectopic parathyroid in the mediastinum underwent surgery with different methods of surgical management.
Hyperparathyroidism diagnosis is usually assisted by parathyroid hormone (PTH) measurement in peripheral blood after resection of a suspected adenoma and by frozen section histology. Intraoperative PTH levels are reduced within 10 min. The PTH levels should fall to at least 50% of the preoperative level or time of gland removal concentrations and should be measured at least for 15 min after excision. If they persist, the ectopic gland or multiple-gland disease is suspected. Seven patients with hyperparathyroidism and ectopic parathyroid glands were identified from a parathyroid database. Laboratory data, gland weights, and surgical outcomes were obtained. The locations of the ectopic glands were correlated with results of technetium-99-m-sestamibi-imaging. Of the operated eight patients with ectopic parathyroid glad, 50% in the anterior mediastinum were treated by video-assisted thoracoscopic surgery, 12.5% in middle mediastinum treated by mediastinoscopy, and 37.5% treated by neck exploration.

Conclusion All glands were successfully identified preoperatively and subsequently resected.
Ectopic mediastinal parathyroid glands may be safely and accurately resected using VATS, and mediastinoscopy, to avoid open approaches.

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Aim

Ectopic parathyroid gland in the mediastinum was successfully resected easily by different methods of minimally invasive thoracic surgery, one of them is video-assisted thoracoscopic surgery (VATS) thoracoscopy and the second one is mediastinoscopy, with good result, and short hospital stay, and this procedure depend on experience in thoracoscopy and mediastinoscopy. Moreover, all patients complaining from generalized boneache for long period should be investigated regarding level of parathyroid hormone (PTH), vitamin D level, and position of parathyroid gland.

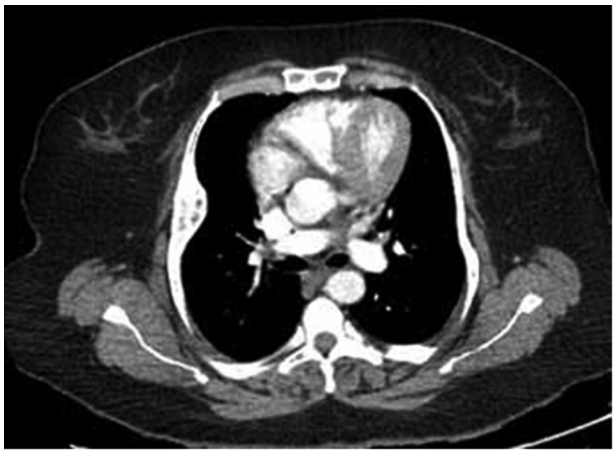
Introduction

Primary hyperparathyroidism (PHPT) caused by ectopic parathyroid adenomas in the mediastinum is uncommon (Fig. 1). The main indications for resection are glandular hyperfunction, complications from hypercalcemia, and symptoms of the patients. A parathyroid adenoma is a benign tumor of the parathyroid gland. It generally causes hyperparathyroidism. PHPT is characterized by excessive secretion of PTH, resulting in a high plasma calcium ion and low phosphate ion concentration. PTH secreted by the parathyroid glands is normally controlled by negative feedback by the plasma calcium ion concentration. Vitamin D levels are reduced in patients with PHPT to combat hypercalcemia. Symptomatic mediastinal parathyroid glands are exceedingly rare, accounting for only 1% of operations for parathyroid disease [1]. The commonest parathyroid pathologies leading to symptomatic disease are adenomas [2]. The parathyroid secretes PTH, which increases the concentration of calcium in the blood by inducing the bones to release calcium into the blood and the kidneys to reabsorb it from the urine into the blood. When a parathyroid adenoma causes hyperparathyroidism, more PTH is secreted, causing the calcium concentration of the blood to rise, resulting in hypercalcemia. The most common clinical presentation of PHPT is asymptomatic hypercalcemia detected by routine biochemical screening. The clinical manifestations that are directly related to PHPT are symptoms and signs of gastrointestinal, neuromuscular, renal, and psychological that are likely related to hypercalcemia.

Figure 1

A 40-year-old female patient presented with soft tissue mass measuring 4.3×2.5 in the anterior mediastinum. Ectopic mediastinal parathyroid.

Figure 2



A 40-year-old female patient with MEP, multiple mixed, lytic sclerotic lesion seen scattered in bones ,examples, lytic ,sclerotic lesion in lower ribs.

Patients with mild hypercalcemia [calcium<12 mg/dl (3 mol/l)] may be asymptomatic, or they may report nonspecific symptoms, such as constipation, fatigue, and depression. Serum calcium of 12–14 mg/dl (3–3.5 mol/l) may be well tolerated chronically, whereas an acute rise to these concentrations may cause marked symptoms, including polyuria, polydipsia, dehydration, anorexia, nausea, and muscle weakness. In patients with severe hypercalcemia [calcium>14 mg/dl (3.5 mol/l)], there is often progression of these symptoms [3]. Mediastinal ectopic parathyroid adenomas (MEPAs) are rare tumors, constituting 1–2% of all parathyroid adenomas [4]. It is also of importance that clinicians should be aware of the advancements in preoperative parathyroid localization, intraoperative PTH monitoring, and the different surgical accesses for MEPAs, including 'focused' parathyroidectomy, bilateral surgical neck exploration, open thoracotomy, median sternotomy, mediastinoscopy, and VATS. The traditional approach to MEPAs has been a trans-sternal approach or lateral thoracotomy [3–5]. VATS is now an established minimally invasive technique for the resection of intrathoracic lesions [6,7].

Patients and methods

Between June 2014 and December 2017, eight patients presented with mediastinal single-gland ectopic hyperparathyroidism. All patient consented before operation for publication. All patient consented before operation for publication. All patients were from KSA and were operated in security force hospital in Riyadh. All patients had PHPT, vitamin D deficiency, and were on therapeutic dose of vitamin D before surgery. All patients had computed tomography (CT) scans of the chest (Fig. 1) and parathyroid scan [technetium 99-m (^{99m}Tc)-sestamibi scan] (Figs 2–5). In this study, eight patients underwent excision of mediastinal ectopic parathyroid (MEPT) gland. Age of the patients ranged from 40 to 66 years, with mean age of 53 years. There were six (75%) female and two (25%) males (Table 1). They were operated under general anesthesia with duple endotracheal tube. All patients underwent thoracoscopy and carbon dioxide (CO_2) insufflation used intraoperatively, which are safe and help to accurately localize the ectopic parathyroid tissue. The group of patients underwent mediastinoscopy under general anesthesia with single-lumen tube and video-assisted mediastinoscopy used (Fig. 6). The ^{99m}Tc-Sestamibi scans appear to allow identification of parathyroid adenoma with a high degree of accuracy (Figs 2–7). The single adenoma surgically removed and confirmed by histopathological examination and frozen section (Figs 5–9). In this study, during surgery the level of PTH highly increased in all patient due to manipulation up to more than 10 times. This was approved by monitoring of PTH in the operating room before skin incision, during surgery and after skin closure (Figs 10–12).

Pre.op

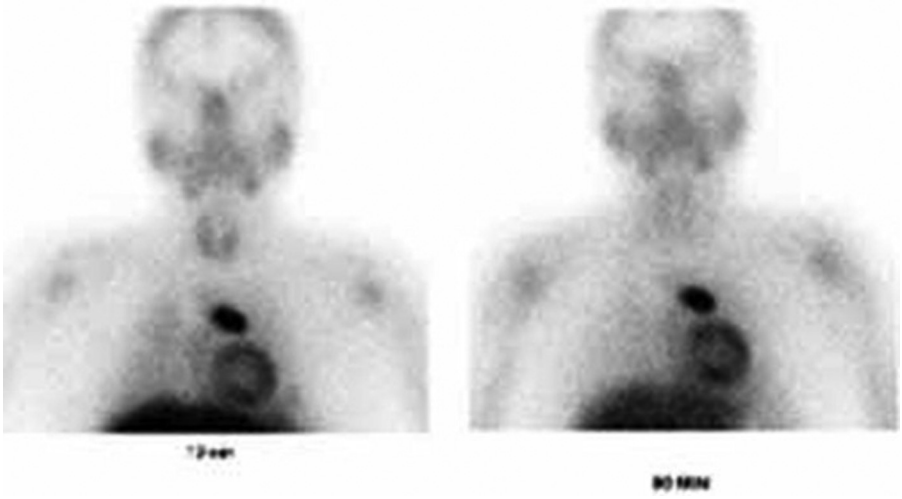
CT CHEST

Histopathology post op.

CT CHEST

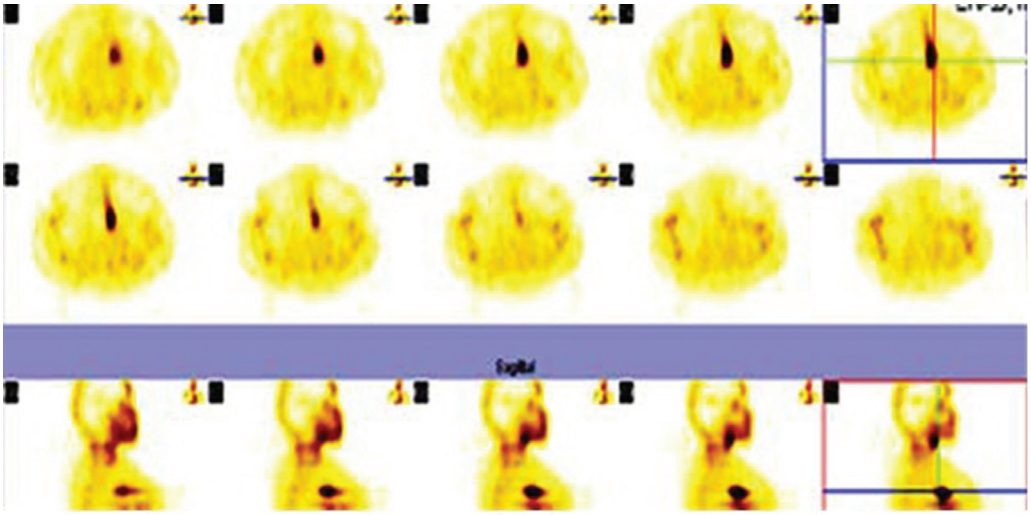
NM PARATHYROID SCAN

Figure 3



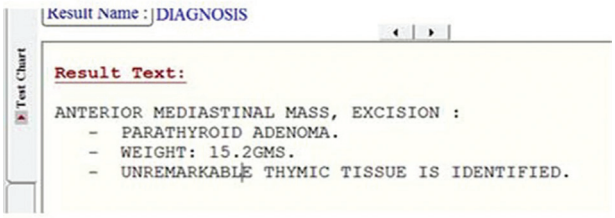
A 40-year-old female patient with parathyroid scan showed ectopic parathyroid in the anterior mediastinum.

Figure 4



A 39-year old male patient with parathyroid scan with parathyroid scan show ectopic parathyroid gland adenoma in the mediastinum.

Figure 5



Histopathology of a 39-year-old male patient with MEPT. MEPT, mediastinal ectopic parathyroid.

HISTOPATHOLOGY POST OP FOR MALE PATIENT 39 YEARS OLD POST RESECTION OF ECTOPIC PARATHYROID IN THE MEDIASTINUM

Female patient 65 years old presented by ectopic parathyroid gland in the anterior mediastinum.

CT NECK AND CHEST

NM PARATHYROID SCAN

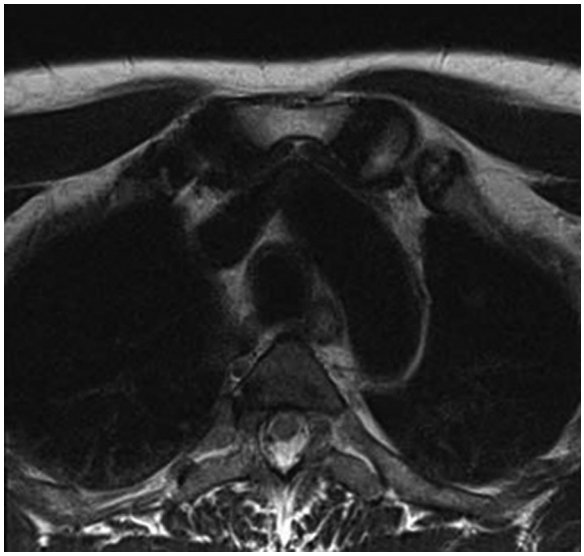
Histopathology post op for female patient 66 years old

All patients provided consented according to the position of the ectopic parathyroid gland.

Table 1 Data sheet

Patients	1	2	3	4	5	6	7	8
Marital status	Married	Married	Married	Married	Married	Married	Single	Married
Blood group	AB+	A+	O+	O+	B+	A+	O+	AB+
Smoking	+	+	–	–	+	+	+	–
Diabetes	+	–	–	–	+	–	–	–
Hypertension	–	–	–	–	–	+	–	–
History of chest or cardiac surgery	–	–	–	–	–	–	–	–
Postoperative ICU admission	–	–	–	–	–	–	–	–
Intraoperative chest tube insertion	+	+	–	–	–	–	–	+
Amount of blood loss				<200 ml				
Postoperative hospital stay (days)	2	4	4	3	4	2	2	3

Figure 6



MRI neck and chest for 39-years old male patient show mass in aortopulmonary window-in middle mediastinum ectopic parathyroid gland.

If the gland is in the anterior mediastinum (Fig. 1), the patient consented for thoracoscopic excision of the gland with possibility of open surgery.

If gland in the middle mediastinum (Figs 13 and 14), the patient consented for mediastinoscopy, with possibility of open surgery.

If the gland was at suprasternal notch (Fig. 15), the patient consented for neck exploration.

The research was approved by the research committee at the security forces hospital (Table 2).

Surgical procedure

Four patients underwent VATS thoracoscopy for excision of MEPT, three patients underwent neck exploration for excision of MEPT, and one patient underwent mediastinoscopy for excision of MEPT according to position of the parathyroid gland.

Patient undergo video-assisted thoracoscopic surgery thoracoscopy

Single lung ventilation was established via a double lumen tube, whereas lung collapse was assisted by CO_2 insufflation in four patients. Intrapleural pressure was maintained at 10 mmHg at low flow, with the anesthetist continuously monitoring hemodynamics. Three ports were fashioned for access: 10 mm for the camera, 5 mm for instruments, and 10-mm utility port.

The choice between access with the patient supine or on the lateral decubitus position is subtle and reflects the need for such experience. Intraoperative experience with CO_2 insufflation and monitoring of PTH are very important during surgery.

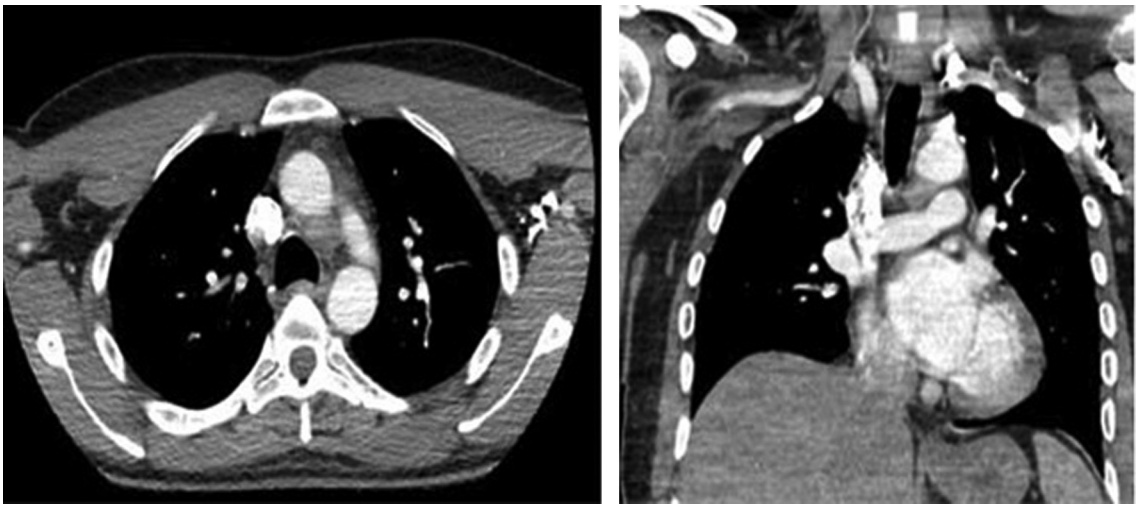
Detailed knowledge of the anatomy of aortopulmonary window and relations of the left recurrent laryngeal nerve remains the domain of thoracic surgeons competent in mediastinal VATS surgery [8,9]. MEPAs can be safely resected by VATS with minimal surgical morbidity, short procedure, and short hospital stay. Chest drainage is either not necessary or could be as short as few days postoperatively. Postoperative stay in hospital is between 3 and 4 days.

Patients undergoing mediastinoscopy

Mediastinoscopy is a procedure that enables visualization of the contents of the mediastinum.

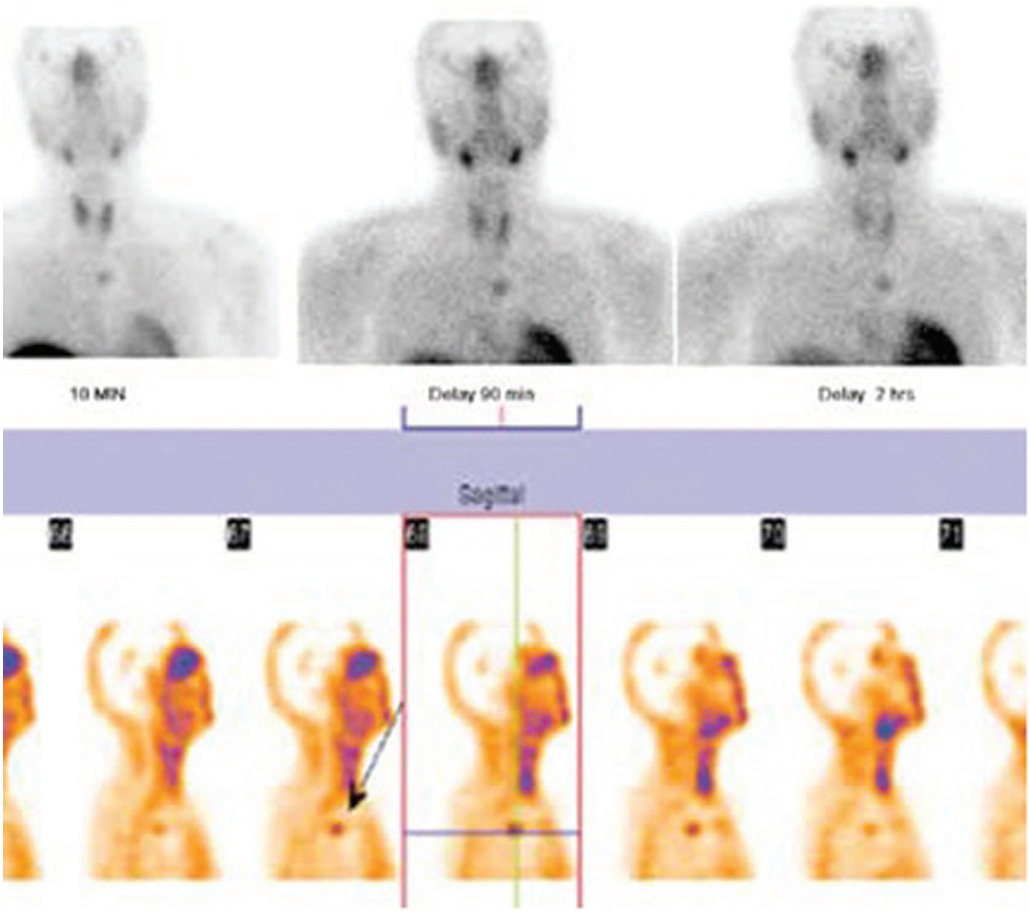
Under general anesthesia, on supine position with neck extension, and using single-lumen tube, transverse incision one finger above, suprasternal notch, then desiccation of muscle in middle line of the neck, until pretracheal fasciae, then mediastinoscopy (Fig. 6), introduce to the mediastinum, in this case the ectopic parathyroid in middle mediastinum.

Figure 7



A 65-year-old female patient presented with ectopic parathyroid gland in meddle mediastinum.

Figure 8



Parathyroid scan of a 40-year-old female patient with MEP. MEPT, mediastinal ectopic parathyroid.

Approximately 10% of parathyroid adenomas are ectopic, located not along the back of the thyroid but elsewhere in the body, sometimes in the mediastinum of the chest [10]. This can make them difficult to locate, so various imaging techniques are used, such as the sestamibi scan (Figs 2–7), ultrasound, MRI (Fig. 13), and CT scans [7].

All patients preoperative had high level of calcium, PTH, and decrease level of vitamin D. Overall, 75% of

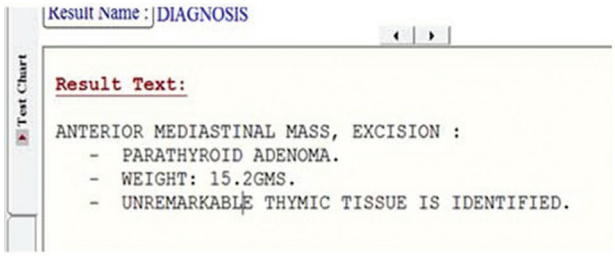
the patients had lower phosphorus level, and 25% had normal level of phosphorus.

Intraoperatively, three patients underwent VATS on left side of chest, and one patient underwent VATS on the right side of the chest. The chest tube was inserted in OR after the procedure and was removed on the second day postoperatively. The other four patients did not need chest tube. Three of them underwent neck exploration, and one underwent mediastinoscopy. Hospital stay postoperatively ranged from 2 to 4 days. Follow-up of the patients postoperatively in the clinic showed correction of calcium, PTH, vitamin D, and phosphorus levels. All patients presented with symptoms that disappeared within 1 week.

Postoperatively

MEPAs higher than the right innominate artery or the origin of the left subclavian artery are likely to be accessible by a cervical approach [11], parathyroid glands secrete PTH, which regulates calcium and phosphate levels in blood. Hyperparathyroidism can be primary due to diseased parathyroid glands, or secondary owing to disease elsewhere, usually kidneys. PHPT can result from benign parathyroid adenomas, hyperplasia of one or more parathyroid glands, or rarely cancerous gland. Overall, 80% of patients are asymptomatic or have minor symptoms related to hypercalcemia, such as fatigue, loss of appetite, nausea, constipation, excessive thirst, mild depression, and loss of concentration. With high calcium levels, patients may develop bilateral recurrent renal stones, bone resorption and fractures, and rheumatologically complications [4,10,12].

Figure 9

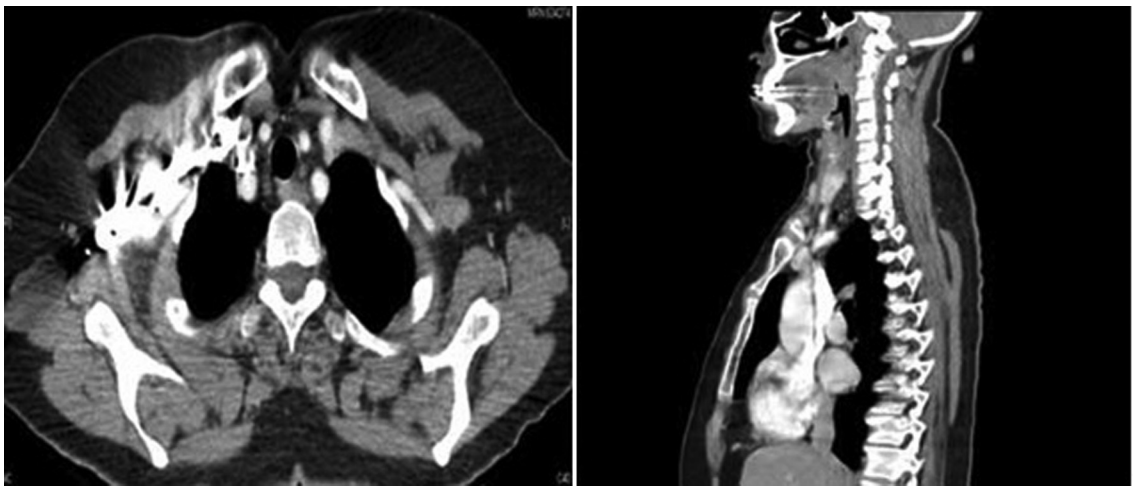


Histopathology postoperatively of a 65-year-old female patient after resection of ectopic mediastinal parathyroid gland.

Results

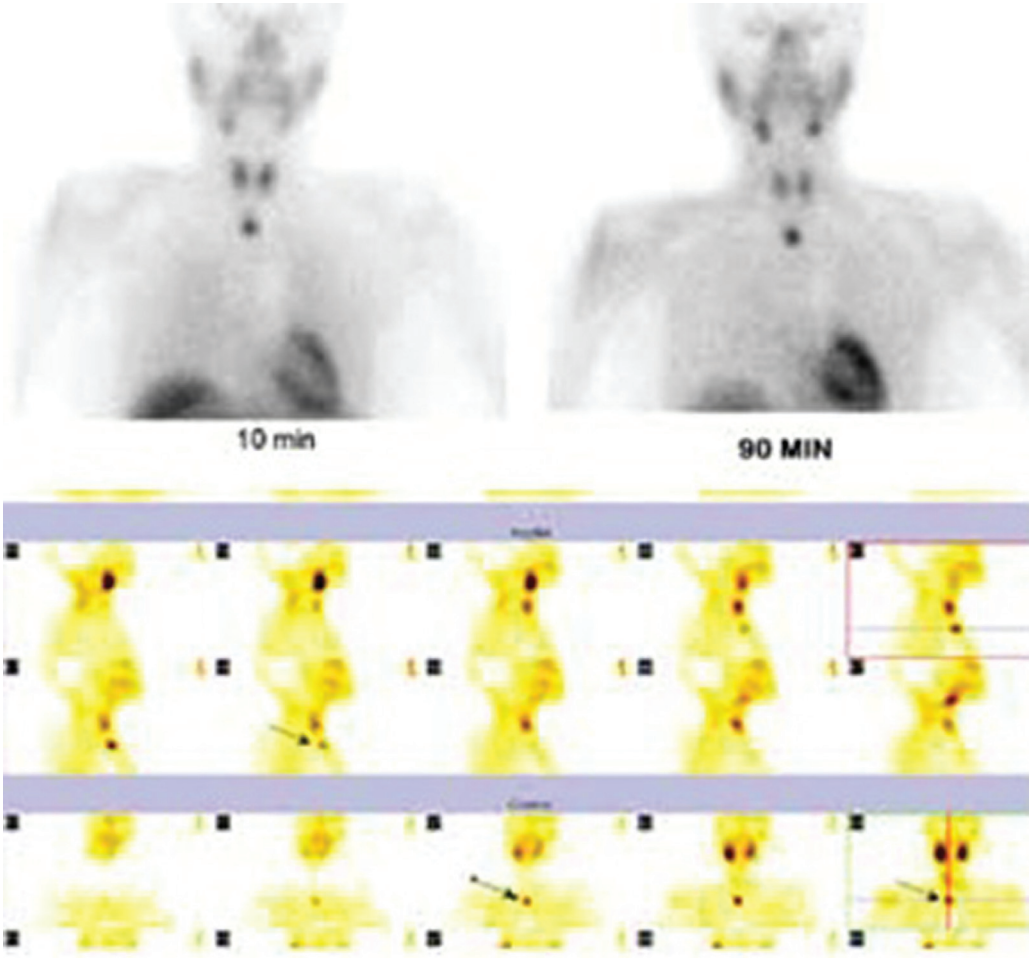
Surgical access and histopathology of ectopic parathyroid was done in SFH in KSA. In this study, eight patients underwent excision of ectopic parathyroid in the mediastinum by different methods (Table 2). In this study, one patient underwent mediastinoscopy (12.5%). The excision of ectopic parathyroid gland in the mediastinum by mediastinoscopy has not been done in other study. In this study, two (25%) patients were discovered accidently during routine investigation. This study also showed the level of elevated PTH has more effect on calcium level than the effect on phosphorous level in the body. The level of vitamin D is more affected by the level of PTH (Table 3). When the level of hormone increases, the level of vitamin D decreases (Figs 16 and 17). All eight (100%) patients showed

Figure 10



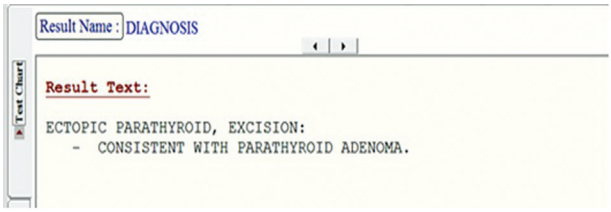
CT chest and neck show soft tissue lesion 2.2 x 1.8 in the anterior mediastinum.

Figure 11



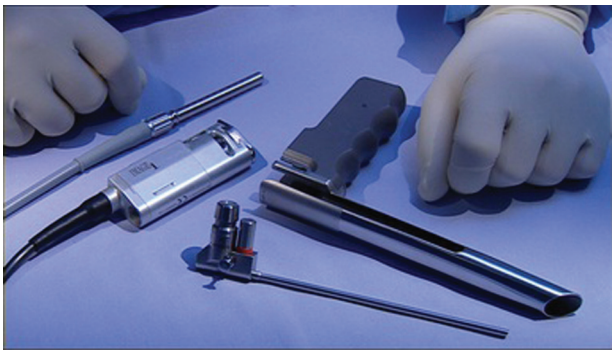
Parathyroid scan show ectopic parathyroid in the mediastinum .

Figure 12



Parathyroid hormone level preoperatively and postoperatively of a 66-year-old female patient who presented with ectopic mediastinal parathyroid gland. High level owing to manipulation during surgery.

Figure 13



This picture of mediastinoscopy.

decreased level of vitamin D preoperatively, which returned to normal within 1 week postoperatively (Figs 16 and 17).

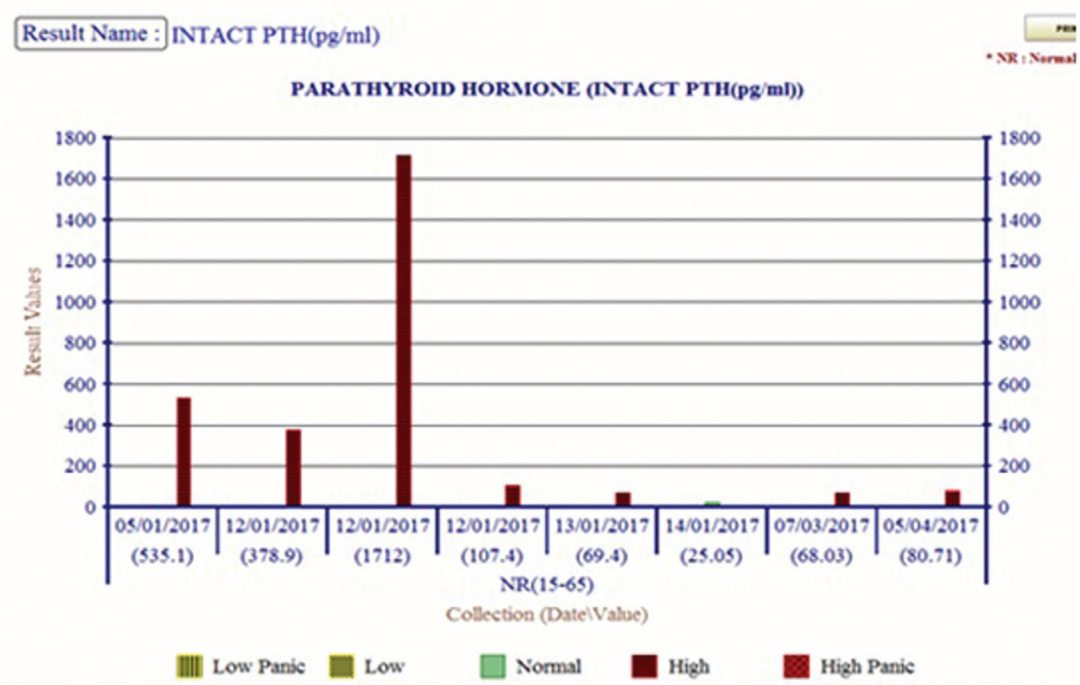
In this study during surgery, the level of PTH highly increased in all patients owing to manipulation up to more than ten times. This was approved by monitoring of PTH in operating room before, during, and after surgery (Figs 10–12).

Parathyroid hormone level preoperatively, intraoperatively, and postoperatively

Parathyroid hormone level

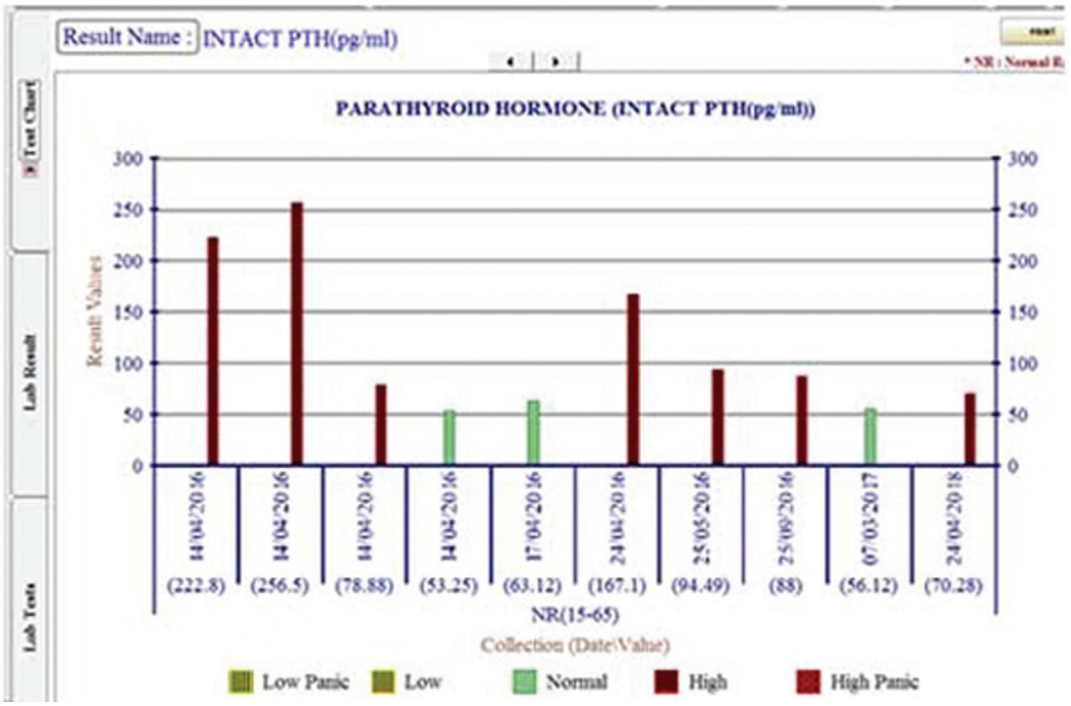
PTH level: this study shows immediately after removal of ectopic parathyroid in operating room, the level of PTH decreases to normal level before closing the

Figure 14



Preoperative, operative and postoperative parathyroid hormone for male patient 39 ears old.

Figure 15



Preoperative and postoperative parathyroid hormone for femal patient 65 years old.

wound (Figs 10–12). All patients on the first day postoperatively showed the PTH, calcium, and vitamin D level retract to normal level (Fig. 18).

Total vitamin D preoperatively and postoperatively

Vitamin D level preoperatively and postoperatively

Calcium level preoperative and postoperative

Moreover, there is marked improvement in clinical symptoms of patient starting from first day postoperatively especially boneache and gastrointestinal symptoms.

Discussion

MEPA causes hyperparathyroidism in ~20% of cases. When the thymus descends into the chest in the fifth week of embryonic development, it is accompanied by the lower parathyroid glands, as they take up their normal position. Occasionally, however, they move to the chest, along with the thymus. The parathyroid secretes PTH, which increases the concentration of calcium (Fig. 18) in the blood by inducing the bones to release calcium into the blood and the kidneys to reabsorb it from the urine into the blood. When a parathyroid adenoma causes hyperparathyroidism, more PTH is secreted, causing the calcium concentration of the blood to rise, resulting in hypercalcemia. Most patients with hyperparathyroidism are asymptomatic, as in Table 1, but any symptoms that do appear are generally caused by hypercalcemia and include nausea, vomiting, excessive thirst, constipation, polyuria, and lethargy. Kidney stones, bone resorption, and pathologic fractures may also occur (Fig. 19). Severity of symptoms correlates with the size of the hyperfunctioning adenoma [3]. When PHPT is suspected, preoperative localization of the tumor by imaging studies is essential for planning the surgical approach and allowing the surgeon to select the most appropriate technique. Ectopic parathyroid adenomas of less than 10 mm in diameter are best detected with ^{99m}Tc-MIBI scintigraphy. Cervical ultrasound, CT, and MRI are used to determine the exact anatomical

Table 2 Different method for surgery

Neck exploration	3	Patient
Thoracotomy	0	Patient
Median sternotomy	0	Patient
Mediastinoscopy	1	Patient
VATS thoracoscopic exploration	4	(3, left side; 1, right side)

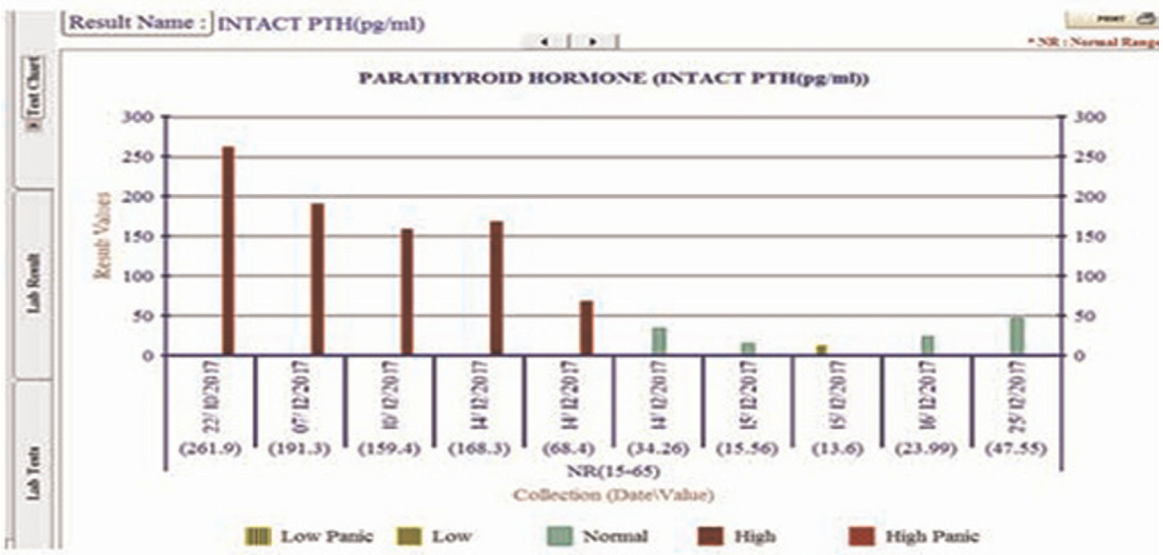
VATS, video-assisted thoracoscopic surgery.

Table 3 Preoperative operative and postoperative data

Histopathology	Access for surgery	Vitamin D level preoperative and postoperative normal range 75–250 mmol/l	Preoperative and postoperative phosphorus level normal range 2.5–4.5 mg/dl	Preoperative and postoperative calcium level normal range 2.15–2.5 mmol/l	Preoperative and postoperative PTH level normal range 15–65 pg/ml	Symptoms of patent	Age sex	*N*
Adenoma	VATS supine position left side thoracoscopy	Preoperative 30 postoperative 79	Preoperative 1.3 postoperative 1.01	Preoperative 2.7 postoperative 2.22–2.31	Preoperative 535 Normal postoperative 25–68	Abdominal pain +constipation	40 female	1
Adenoma	Mediastinoscopy by using mediastinoscopy	Preoperative 25 postoperative 146	Preoperative 0.66 postoperative 1.17–1.23	Preoperative 2.6 postoperative 2.1–2.3	Preoperative 222.5 postoperative 53.25–63.12	Generalized boneache	39 male	2
Adenoma	Thoracoscopy left side lateral position	Preoperative 24.24 postoperative 100.4	Preoperative 0.73 postoperative 0.97	Preoperative 2.92 postoperative 2.33	Preoperative 261.9 postoperative 23.33	Accidently discovered	66 female	3
Adenoma	Neck exploration	Preoperative 26.9 postoperative 196	Preoperative 0.69 postoperative 1.06	Preoperative 2.92 postoperative 2.3	Preoperative 261 postoperative 48.2	Abdominal pain vomiting	66 female	4
Adenoma	Right side thoracoscopy	Preoperative 25 postoperative 100.5	Preoperative 0.7 postoperative 0.92	Preoperative 2.93 postoperative 2.2	Preoperative 190 postoperative 56	Accidentally discovered	48 male	5
Adenoma	Neck exploration	Preoperative 33 postoperative 123	Preoperative 0.8 postoperative 1.1	Preoperative 2.8 postoperative 2.15	Preoperative 200.5 postoperative 61	Nausea constipation	47 female	6
Adenoma	Neck exploration	Preoperative 47 postoperative 134	Preoperative 0.86 postoperative 1.0	Preoperative 2.9 postoperative 2.3	Preoperative 199 postoperative 55	Boneache easy fatigability	63 female	7
Adenoma	Left side thoracoscopy	Preoperative 33 postoperative 115	Preoperative 0.78 postoperative 1.0	Preoperative 0.78 postoperative 1.0	Preoperative 210 postoperative 66	Multiple bone fracture	59 female	8

PTH, parathyroid hormone; VATS, video-assisted thoracoscopic surgery.

Figure 16



A 40-year-old female patient preoperative and postoperative parathyroid hormone.

Figure 17

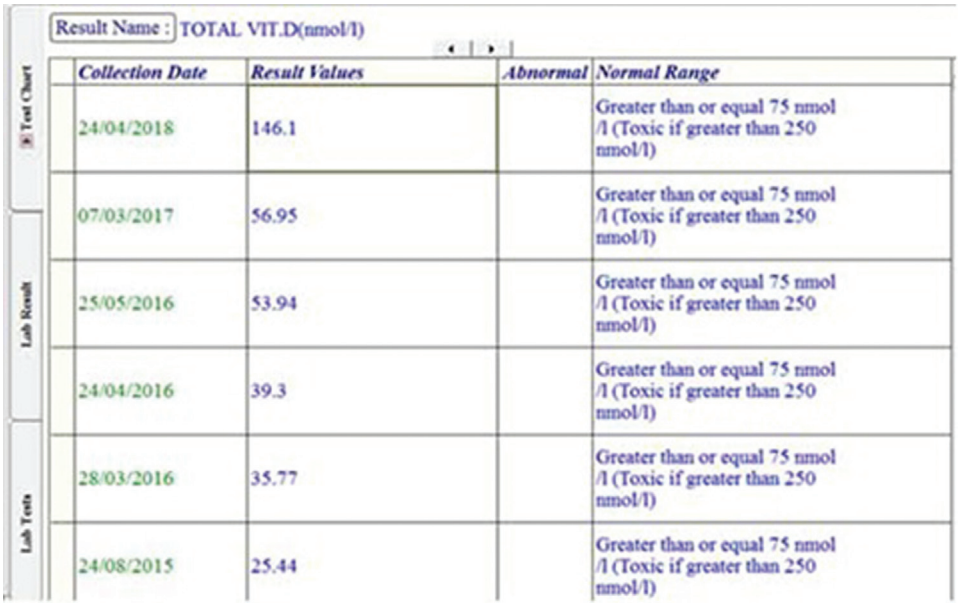
Result Name : TOTAL VIT.D(nmol/l)

Collection Date	Result Values	Abnormal	Normal Range
05/04/2017	79.38	D	Greater than or equal 75 nmol /l (Toxic if greater than 250 nmol/l)
05/01/2017	30		Greater than or equal 75 nmol /l (Toxic if greater than 250 nmol/l)

Vitamin D level preoperatively and postoperatively of a 65-year-old female patient presented by ectopic mediastinal parathyroid gland preoperatively and postoperatively.

site of the mass [5]. Conventional approaches for a parathyroid adenoma located deep in the mediastinum are median sternotomy, manubriotomy, or thoracotomy [13]. Thanks to recent advances, however, VATS is now more widely used for the resection of MEPAs. Mediastinoscopy (Fig. 6) is also used in this study to assess hypercalcemia parathyroid glands secrete PTH, which regulates calcium and phosphate levels in blood (Fig. 18). Hyperparathyroidism can be primarily caused by diseased parathyroid glands, or secondarily caused by disease elsewhere, usually kidneys. PHPT can result from benign parathyroid adenomas, hyperplasia of one or more parathyroid glands, or rarely cancerous gland. Overall, 80% of patients are asymptomatic or have minor symptoms related to hypercalcemia. We conclude that MEPAs can be safely resected by VATS with minimal surgical morbidity, short procedure, and short hospital stay. Chest drainage is either not necessary or could be as short as few days postoperatively. CO_2 insufflation helps in exposure of ectopic parathyroid intraoperatively. Patients with mediastinal adenoma differ substantially from cervical cases and require a specific strategy. VATS should be considered as the first-line approach for resection of these ectopic tumors [11,14]. Anatomical mediastinal location of the tumor dictates the surgical approach. Traditionally, before the introduction of VATS, mediastinal MEPAs were resected by thoracotomy or median sternotomy [4,13]. VATS offers significant advantages over both [6,10]. It allows better visualization of the tumor, a shorter operative time, shorter chest tube time and shorter. MEPAs higher than the right innominate artery or the origin of the left subclavian artery are likely to be accessible by a cervical approach [15]. Hospital stay in this procedure very short compared wit sternotomy. Informed patients prefer the superior cosmetic result compared with sternotomy and thoracotomy scars. In reported series of PHPT, the incidence of MEPAs is about 1–2% [4,5]. The Mayo clinic reported 33 cases of mediastinal parathyroidectomy between March 1980 and 15 September 2010, a 30-year span [6]. The two hospitals involved in this report serve a population of 3.3 million in the South West of the UK. In the same reporting period, there have been 132 cases of cervical exploration for hyperthyroidism and two sternotomies for MEPAs [6]. Ectopic parathyroid adenoma is a common cause of unsuccessful surgery with persistent hypercalcemia [15]. Accurate localization of the EPA is warranted for a successful reoperation. Failure rate after standard initial neck exploration surgery is 5–10% [16]. Several causes have been identified for the failure rate, including a multinodular goiter, poor surgical technique, pathological misdiagnosis, and ectopic glands (Table 4)

Figure 18



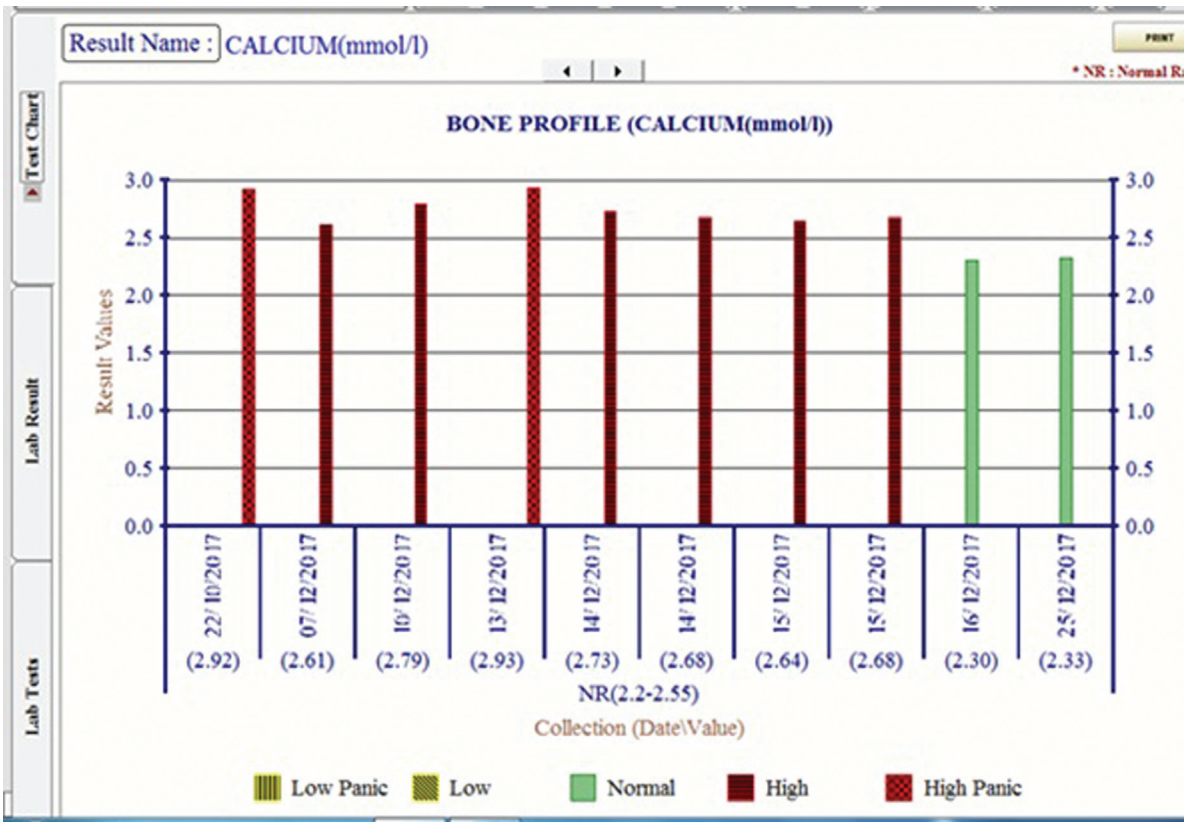
Result Name : TOTAL VIT.D(nmol/l)

Test Chart | Lab Result | Lab Tests

Collection Date	Result Values	Abnormal	Normal Range
24/04/2018	146.1		Greater than or equal 75 nmol /l (Toxic if greater than 250 nmol/l)
07/03/2017	56.95		Greater than or equal 75 nmol /l (Toxic if greater than 250 nmol/l)
25/05/2016	53.94		Greater than or equal 75 nmol /l (Toxic if greater than 250 nmol/l)
24/04/2016	39.3		Greater than or equal 75 nmol /l (Toxic if greater than 250 nmol/l)
28/03/2016	35.77		Greater than or equal 75 nmol /l (Toxic if greater than 250 nmol/l)
24/08/2015	25.44		Greater than or equal 75 nmol /l (Toxic if greater than 250 nmol/l)

Preop5rative and postoperative level of vitamin D.

Figure 19



Preoperative and postoperative level of calcium.

[17]. Any hypercalcemia and high level of PTH without parathyroid adenoma in the neck should alert physicians to search for ectopic locations through combination of imaging techniques. The mediastinum should be cautiously noted as it is the very common location for ectopic parathyroid adenoma. As parathyroid crisis is life threatening and its prognosis is poor, it requires aggressive medical therapy and early surgical

Table 4 Histopathology

Normal gland	0
Hyperplasia	0
Adenoma	8
Carcinoma	0

treatment [4]. The combination of imaging techniques has incremental value in localizing ectopic parathyroid adenomas over either technique alone [9].

Conclusion

MEPAs can be safely resected using VATS with minimal surgical morbidity, short drainage time, and short hospital stay. CO_2 insufflation intraoperative helps in accurately localizing the ectopic adenoma. VATS should be considered as the first-line approach for resection of MEPAs. Patients with MEPA differ substantially from cervical cases and require a specific strategy. VATS should be considered as the first-line approach for resection of these ectopic tumors. We conclude that MEPAs can be safely resected by VATS with minimal surgical morbidity, short procedure, and short hospital stay. Chest drainage is either not necessary or could be as short as few days postoperatively. If the ectopic parathyroid is in middle mediastinum, the gland is resected by small suprasternal notch incision by using mediastinoscopy, with good result without using chest tube.

So the ectopic parathyroid in the mediastinum should be resected by thoracoscopy or mediastinoscopy according to experience in this field. Moreover, all patients complaining from boneache should be investigated to detect any abnormality in the parathyroid gland and position of it.

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References

1 Zamboni WA, Folse R. Adenoma weight: a predictor of transient hypocalcemia after parathyroidectomy. *Am J Surg* 1986; **152**:611–615.

2 Zald PB, Hamilton BE, Larsen ML, Cohen JI. The role of computed tomography for localization of parathyroid adenomas. *Laryngoscope* 2008; **118**:1405–1410.

3 Obara T, Fujimoto Y, Tanaka R. Mid-mediastinal parathyroid lesions: preoperative localization and surgical approach in two cases. *Jpn J Surg* 1990; **20**:481–486.

4 Edits AJ, Sheedy PF, Beahrs OH, *et al.* Results of reoperation for hyperparathyroidism, with evaluation of preoperative localization studies. *Surgery* 1978; **84**:384–393.

5 Conn JM, Goncalves MA, Mansour KA. The mediastinal parathyroid. *Am Surg* 1991; **57**:62–66.

6 Organ CHJr. The history of parathyroid surgery, 1850-1996: The Excelsior Surgical Society 1998 Edward D Churchill Lecture. *J Am Coll Surg* 2000; **191**:284–299.

7 Said SM, Cassivi SD, Allen MS. Minimally invasive resection for mediastinal ectopic parathyroid glands. *Ann Thorac Surg* 2013; **96**:1229–1233.

8 Bellantone R, Raffaelli M, DE Crea C, Traini E, Lombardi CP. Minimally-invasive parathyroid surgery. *Acta Otorhnolaryngol Ital* 2011; **31**:207–215.

9 Caixas A, Berna L, Piera J, *et al.* Utility of ^{99m}Tc-sestamibiscintigraphy as a first-line imaging procedure in the preoperative evaltation of hyperparathyroidism. *Clin Endocrinol (Oxford)* 1995; **43**:525–530.

10 Taira N, Doihara H, Hara F, Shien T, Takabatake D, Takahashi H. Less invasive surgery for primary hyperparathyroidism based on preoperative 99mTc-hexakis-2 methoxyisobutylisonitrile imaging findings. *Surg Today* 2004; **34**:197–203.

11 Sofferman RA, Nathan MH, Fairbank JT, Foster RS, Krag DN. Preoperative technetium 99m sestamibi imaging: paving the way to minimal-access parathyroid surgery. *Arch Otolaryngol Head Neck Surg* 1996; **122**:369–374.

12 Downey NJ, McGuigan JA, Dolan SJ. Median sternotomy for parathyroid adenoma. *Ir J Med Sci* 1999; **168**:13–16.

13 Russell CF, Edis AJ, Scholz DA. Mediastinal parathyroid tumors: experience with 38 tumors requiring mediastinotomy for removal. *Ann Surg* 1981; **193**:805–809.

14 Casas AT, Burke GJ, Sathyanarayana XX, Mansberger ARJr, Wei JP. Prospective comparison of technetium Tc 99m setamibi/iodine-123 radionuclide scan vs high-resolution ultrasonography for the preoperative localization of abnormal parathyroid glands in patients with previously unoperatic primary hyperparathyroidism. *Am J Surg* 1993; **166**:369–373.

15 O'Doherty MJ, Kittle AG, Wells P, Collins REC, Coakley AJ. Parathyroid imaging with technetium Tc 99m sestamibi: preoperative localization and tissue uptake studies. *J Nucl Med* 1992; **33**:313–318.

16 Dsouza C, Gopalakrishnan X, Bhagavan KR, Rakesh K. Ectopic parathyroid adenoma. *Thyroid Res Pract* 2012; **16**:68–70.

17 Billy HT, Rimkus DR, Hartzman S, Latimer RG. Technetium Tc 99m sestamibi single agent localization vs high-resolution ultrasonography for the preoperative localization of parathyroid glands in patients with primary hyperparathyroidism. *Am Surg* 1995; **61**:882–888.