Localisation studies

Localisation studies

- Historically , preoperative localisation studies for PHPT were considered less important than identifying an experienced surgeon. However, with a shift away from the traditional four- gland (cervical neck) exploration to more minimally invasive procedures, accurate preoperative identification is critically important to guide surgical strategy . There are a variety of both non-invasive and invasive studies commonly in use. Non-invasive radiology includes nuclear medicine-based studies, ultrasonography and four- dimensional (4D) computed tomography (CT) scanning. Invasiv e imaging is largely reserved for reoperative surgery and includes ultrasound or CT-guided fine-needle aspiration with

In my opinion, the only localising study required in a patient with untreated primary hyperparathyroidism is to localise an experienced parathyroid surgeon. John Doppman, 1986

venous sampling for the PTH gradient. Nuclear medicine-based studies (sestamibi scanning) The use of sestamibi (2-methoxy-2-methylpropylisonitrile [MIBI]) for parathyroid localisation was first described in 1989 and is now regarded as the most accurate and reliable method for imaging the parathyroid glands. It is safe and reproducible and, while it has a sensitivity and specificity similar to ultra sonography , it may image glands in ectopic positions better (Figure 56.3a). Sestamibi accumulates in mitochondria and therefore washes out at di ff erential rates depending on the number of mitochondria within individual tissues. Para thyroid adenomas often have a high concentration of oxyphilic cells with high mitochondrial content. T hese retain tracer, and adenomas are therefore associated with a slow washout when compared with the thyroid gland. There are three di ff erent protocols for ses tamibi scanning: single-isotope dual-phase scan, dual-isotope Karl Hürthle , 1866–1945, histopathologist, Breslau, Germany (now Wroc ł aw , Poland). tomography (SPECT). The sensitivity and specificity of ses - tamibi, regardless of the protocol used, are 79% and 90%, respectively . False positives are rare but may arise from some solid thyroid nodules, such as Hürthle cell nodules, that are associa ted with high oxyphilic content. These can be reduced by the addition of a thyroid-specific radioactive tracer, such as 99 Tc-pertechnetate and subsequent subtraction images. Ultrasonography - Ultrasonography is a non-invasive, inexpensive method of imaging the parathyroid glands (Figure 56.3b). Parathyroid adenomas are typically oval or elongated, bi- or multilobed hypoechoic structures. Rarely , adenomas may be cystic or heterogeneous in nature. Giant adenomas are described as those over 3 /uni00A0 cm in size. Ultrasonography is not associated with any radiation exposure and has the advantage of being able to identify and facilitate biopsy of any concomitant thyroid - pathology . However, ultrasonography is operator, lesion size and location dependent. Critically , ultrasonography may

(a) Figure 56.3 Sestamibi scan (a) demonstrating right inferior adenoma, with concordant ultrasonography (b) . (b) or retrotracheal areas. It can also be di ffi cult to di ff erentiate between a small parathyroid gland and a normal-appearing lymph node. A meta-analysis of preoperative localisation techniques in PHPT demonstrated that ultrasonography and sestamibi-SPECT have comparable accuracy , with pooled sensitivities of 76.1% and 78.9%, respectively , and positive predictive values (PPVs) of 93.2% and 90.7%, respectively (Krakauer et al ., 2016). Four-dimensional computed tomography scanning/positron emission tomography– computed tomography Multiphase CT imaging (4D-CT) has become widely utilised to localise disease (Figure 56.4). It gives both anatomical and functional information about the parathyroid glands. Using precontrast, postcontrast and delayed images, it demonstrates not only detailed anatomical localisation but, combined with rapid uptake and washout, allows hyperfunctioning glands to be di ff erentiated from lymph nodes that demonstrate a progressive enhancement pattern. The potential disadvantage of 4D-CT scanning is the higher radiation dose when compared with traditional imaging modalities. Modification of the protocol now allows fewer phases to be obtained without compromising outcomes. The initial study in 2006 reported a sensitivity of 88% for lateralisation and 70% for localisation of parathyroid adenomas (Rodgers et al ., 2006). A more recent meta-analysis, although limited by the small number of studies, demonstrated a sensitivity and PPV of 89.4% and 93.5%, respectively , when 4D-CT was used as the primary imaging modality . This was reduced to 71.8% and 74.9%, respectively , in cases of negative or inconclusive prior imaging (Cheung et al ., 2012). Positron emission tomography (PET) scanning remains expensive and is not widely available. However, recent data 18 suggest that there may be an incr emental value to F-fluoro choline PET with the addition of CT scanning for localisation of ectopic adenomas. Magnetic resonance imaging Magnetic resonance imaging (MRI) is not commonly used to image the parathyroid glands. However, on T2-weighted images, enlarged parathyroid glands demonstrate significantly increased intensity . In reoperative cases or where the adenoma is located in the mediastinum, MRI may be beneficial, with higher reported sensitivities (50–88%). While the sensitivity of MRI is slightly better than that for CT (64–88%) in primary disease, it has significant limitations. It is expensive, patients can be poorly compliant owing to claustrophobia and the resolution for normal glands or adenomas <5 /uni00A0 mm is poor. Similarly , it can be di ffi cult to localise superior glands because of their posterior location, which allows them to be obscured by the thyroid gland. Parathyroid angiography and venous sampling for parathyroid hormone Parathyroid angiography is reserved for reoperative cases and is now rarely required owing to improvements in non-invasive imaging modalities. It involves examination of - both thyrocervical trunks, both internal mammary arteries and both carotids, with occasional selective superior thyroid artery catheterisation. Vascular parathyroid adenomas appear as a persistent oval or round ‘stain’ on angiography . Serious complications such as contrast-induced renal failure, embolisation and neurological damage have limited its utility . Selective venous sampling for PTH can allow accurate localisation of adenomas but an experienced interventional radiologist is vital for success. The venous drainage of the lesion is established when there is a twofold drop in the PTH betw een the sampled blood and the serum PTH. The sensitiv - ity is reported to be 80% and is equally e ff ective in localising cervical and mediastinal adenomas. However, the false-positive to reoperative rate of between 6% and 18% limits its utility cases.

(b) Figure 56.4 (a, b) Four-dimensional computed tomography scanning demonstrating a right inferior parathyroid adenoma (arrows).

Surgical management The mainstay of treatment for PHPT is surgery , addressing the underlying aetiology and allowing not only resolution of biochemical abnormalities but also sustained improvements in end-organ damage. Traditionally a bilateral cervical explora tion was performed with reported cure rates of 95–98%. With improvements in preoperative radiological localisation, a more minimally invasive approach has been developed and widely adopted (Figure 56.5). All symptomatic patients should be o ff ered surgery . An expert panel published recommendations on which asymp tomatic patients should be considered for surgical intervention (Table 56.2). Guidelines from the American Association of Endocrine Surgeons have more liberal indications for surgery . These included patients with cognitive or psy chiatric symp toms attributable to PHPT , cardiovascular disease (excluding hypertension) and more non-specific symptoms, such as muscle weakness, impaired functional capacity and abnormal sleep patter ns. When criteria have been met and where a single ade noma has been confidently identified by radiological means, a /uni25CF /uni25CF /uni25CF /uni25CF versely , where there is discordant imaging or where imaging fails to identify any parathyroid abnormalities, then a bilateral neck exploration and a three-and-a-half-gland parathyroidec - tomy or a four -gland parathyroidectomy and autotransplanta - tion should be performed. Consent for a parathyroidectomy must include the - possibility of recurrent laryngeal nerve damage (risk <1%), permanent hypoparathyroidism (requiring lifelong calcium and vitamin D supplementation; risk 0.5%) and persistent (5%) or recurrent hyperparathyroidism. Persistent disease is defined as an elevated serum calcium within 6 weeks of surgical intervention and recurrent disease is defined as an increase in - calcium levels after 6 months but with an intervening period of normocalcaemia. Minimally invasive (focused) parathyroidectomy - Minimally invasive approaches are based on the principle that over 80% of individuals with PHPT have a single adenoma. Although there is no strict definition of the procedure, it commonly refers to the removal of a localised abnormal - parathyroid gland through an incision less than 3 /uni00A0 cm in length (Figure 56.6). The term encompasses open approaches (central and lateral incisions) and video-assisted and radio- guided parathyroidectomies. A number of randomised studies have shown that the focused approach has similar cure rates to

TABLE 56.2 Consensus guidelines for surgical intervention in asymptomatic primary hyperparathyroidism. Measurement of 0.25 /uni00A0 mmol/L (1.0 /uni00A0 mg/dL)

above the upper limit serum calcium of normal Skeletal BMD by DEXA; T score –2.5 at lumbar spine, total hip, femoral neck or distal one- third of radius Vertebral fracture Renal Creatinine clearance <60 /uni00A0 mL/min 24-hour urinary calcium >10 /uni00A0 mmol/dL (>400 /uni00A0 mL/day) or increased risk of stone formation by risk analysis Age <50 years BMD, bone mineral density; DEXA, bone densitometry. Adapted from Bilezikian et al . (2014). Concordant Discordant MIBI and US imaging imaging Pre-op marking 4D CT with US Pre-op 4 gland MIP marking with exploration US and MIP Figure 56.5 Localisation paradigm and management strategies. 4D /uni00A0 CT, four-dimensional computed tomography; MIBI, 2-methoxy-2 methylpropylisonitrile; MIP , minimally invasive parathyroidectomy; US, ultrasonography. (a) (b)

Figure 56.6 (a) Minimally invasive parathyroidectomy through a lateral approach; (b) the excised parathyroid adenoma.

hypocalcaemia, shorter operating times, potentially less pain and better cosmesis. The need to convert from a focused to a cervical explora tion may be guided by the use of intraoperative PTH mea surements. Routine use is, however, controversial owing to high false-positive and false-negative rates. The basic concept is that the half-life of circulating PTH is 3–5 minutes and there should therefore be a significant dr op detected in the plasma PTH following resection of a single adenoma. If no such drop is detected, then multigland disease may be sus pected and conversion to a bilateral neck exploration should be considered. The Miami criteria were developed to determine the extent of resection. A drop in the PTH into the normal range and to less than half the maximum preoperative PTH at 10 /uni00A0 minutes appears to accurately predict single-gland disease (Figure 56.7). Bilateral neck exploration A traditional cervical neck exploration is required where imaging is negative or discordant, in MEN (type 1 or type 2A) or in lithium-induced PHPT . A transverse collar (Kocher’s) incision is made and the subplatysmal plane developed. The deep cervical fascia is divided between the strap muscles and these are retracted. The thyroid lobes are mobilised and the middle thyroid vein may be divided when present. Identification of the recurrent laryngeal nerve and the middle thyroid artery allows a starting point for a systematic exploration (see Chapter 55). All four glands are identified. Three and a half glands ar e resected, with half of a vascularised parathyroid left in situ . The other half of the gland should be sent for frozen section to confirm the presence of parathyroid tissue (Figure 56.8). Ideally the most normal-appearing parathyroid is left in situ . With this caveat in mind, where possible an inferior gland should be left. It is marked with a non-absorbable suture to aid identification in the presence of recurrent disease, where resection can be achieved without increasing the risk of damage to the recurrent laryngeal nerve. Alternatively , all four glands can be resected and a forearm autotransplant created. Small pieces of parathyroid are sutured into pockets created in the brachioradialis muscle. Cure rates and rates of persistent and recurrent disease appear to be similar, regardless of the Emil Theodor Kocher , 1841–1917, surgeon, Berne, Switzerland, awarded the Nobel Prize in Physiology or Medicine in 1909 for his research on the thyroid. - - - type of procedure used. However, in recurrent disease it can be di ffi cult to identify the location of the recurrent tissue when an autotransplant is performed. Thymectomy and resection of mediastinal adenomas The incidence of clinically significant supernumerary glands is increased in patients with multigland disease or those with hereditary syndromes. A thymectomy should be routinely undertaken for patients with MEN1 -associated PHPT or in secondary hyperparathyroidism. A cervical thymectomy is performed by dissecting close to the thymic capsule, exploring the cervical part of the gland. The mediastinal part of the gland can be removed by gentle upwards traction, with ligation of the veins draining into the innominate vein. The end of the

120 100 80 60 40 20 % PTH remaining 0 0 5 10 15 Time (min) Figure 56.7 Miami criteria for intraoperative parathyroid hormone (PTH) measurement. Drop of PTH into the normal range and less than half the maximum value at 10 minutes postresection. (b) Figure 56.8 Parathyroidectomy with exposure of the left superior and inferior parathyroid glands (white arrows) in situ (a) and left superior gland mobilised on its vascular pedicle (b) .

sternotomy is not required where a prophylactic thymectomy is being performed. Mediastinal adenomas are rare, accounting for less than 1% of all parathyroid adenomas. They will be typically identi fied on preoperative imaging. Resection can be achieved either b y an open sternotomy or increasingly by a thoracoscopic approach. A minimally invasive approach can be particularly e ff ective where the abnormal gland lies immediately deep to the mediastinal pleura. It can confer significant advantages in length of hospital stay and complication rates. Localisation studies

- Historically , preoperative localisation studies for PHPT were considered less important than identifying an experienced surgeon. However, with a shift away from the traditional four- gland (cervical neck) exploration to more minimally invasive procedures, accurate preoperative identification is critically important to guide surgical strategy . There are a variety of both non-invasive and invasive studies commonly in use. Non-invasive radiology includes nuclear medicine-based studies, ultrasonography and four- dimensional (4D) computed tomography (CT) scanning. Invasiv e imaging is largely reserved for reoperative surgery and includes ultrasound or CT-guided fine-needle aspiration with

In my opinion, the only localising study required in a patient with untreated primary hyperparathyroidism is to localise an experienced parathyroid surgeon. John Doppman, 1986

venous sampling for the PTH gradient. Nuclear medicine-based studies (sestamibi scanning) The use of sestamibi (2-methoxy-2-methylpropylisonitrile [MIBI]) for parathyroid localisation was first described in 1989 and is now regarded as the most accurate and reliable method for imaging the parathyroid glands. It is safe and reproducible and, while it has a sensitivity and specificity similar to ultra sonography , it may image glands in ectopic positions better (Figure 56.3a). Sestamibi accumulates in mitochondria and therefore washes out at di ff erential rates depending on the number of mitochondria within individual tissues. Para thyroid adenomas often have a high concentration of oxyphilic cells with high mitochondrial content. T hese retain tracer, and adenomas are therefore associated with a slow washout when compared with the thyroid gland. There are three di ff erent protocols for ses tamibi scanning: single-isotope dual-phase scan, dual-isotope Karl Hürthle , 1866–1945, histopathologist, Breslau, Germany (now Wroc ł aw , Poland). tomography (SPECT). The sensitivity and specificity of ses - tamibi, regardless of the protocol used, are 79% and 90%, respectively . False positives are rare but may arise from some solid thyroid nodules, such as Hürthle cell nodules, that are associa ted with high oxyphilic content. These can be reduced by the addition of a thyroid-specific radioactive tracer, such as 99 Tc-pertechnetate and subsequent subtraction images. Ultrasonography - Ultrasonography is a non-invasive, inexpensive method of imaging the parathyroid glands (Figure 56.3b). Parathyroid adenomas are typically oval or elongated, bi- or multilobed hypoechoic structures. Rarely , adenomas may be cystic or heterogeneous in nature. Giant adenomas are described as those over 3 /uni00A0 cm in size. Ultrasonography is not associated with any radiation exposure and has the advantage of being able to identify and facilitate biopsy of any concomitant thyroid - pathology . However, ultrasonography is operator, lesion size and location dependent. Critically , ultrasonography may

(a) Figure 56.3 Sestamibi scan (a) demonstrating right inferior adenoma, with concordant ultrasonography (b) . (b)

or retrotracheal areas. It can also be di ffi cult to di ff erentiate between a small parathyroid gland and a normal-appearing lymph node. A meta-analysis of preoperative localisation techniques in PHPT demonstrated that ultrasonography and sestamibi-SPECT have comparable accuracy , with pooled sensitivities of 76.1% and 78.9%, respectively , and positive predictive values (PPVs) of 93.2% and 90.7%, respectively (Krakauer et al ., 2016). Four-dimensional computed tomography scanning/positron emission tomography– computed tomography Multiphase CT imaging (4D-CT) has become widely utilised to localise disease (Figure 56.4). It gives both anatomical and functional information about the parathyroid glands. Using precontrast, postcontrast and delayed images, it demonstrates not only detailed anatomical localisation but, combined with rapid uptake and washout, allows hyperfunctioning glands to be di ff erentiated from lymph nodes that demonstrate a progressive enhancement pattern. The potential disadvantage of 4D-CT scanning is the higher radiation dose when compared with traditional imaging modalities. Modification of the protocol now allows fewer phases to be obtained without compromising outcomes. The initial study in 2006 reported a sensitivity of 88% for lateralisation and 70% for localisation of parathyroid adenomas (Rodgers et al ., 2006). A more recent meta-analysis, although limited by the small number of studies, demonstrated a sensitivity and PPV of 89.4% and 93.5%, respectively , when 4D-CT was used as the primary imaging modality . This was reduced to 71.8% and 74.9%, respectively , in cases of negative or inconclusive prior imaging (Cheung et al ., 2012). Positron emission tomography (PET) scanning remains expensive and is not widely available. However, recent data 18 suggest that there may be an incr emental value to F-fluoro choline PET with the addition of CT scanning for localisation of ectopic adenomas. Magnetic resonance imaging Magnetic resonance imaging (MRI) is not commonly used to image the parathyroid glands. However, on T2-weighted images, enlarged parathyroid glands demonstrate significantly increased intensity . In reoperative cases or where the adenoma is located in the mediastinum, MRI may be beneficial, with higher reported sensitivities (50–88%). While the sensitivity of MRI is slightly better than that for CT (64–88%) in primary disease, it has significant limitations. It is expensive, patients can be poorly compliant owing to claustrophobia and the resolution for normal glands or adenomas <5 /uni00A0 mm is poor. Similarly , it can be di ffi cult to localise superior glands because of their posterior location, which allows them to be obscured by the thyroid gland. Parathyroid angiography and venous sampling for parathyroid hormone Parathyroid angiography is reserved for reoperative cases and is now rarely required owing to improvements in non-invasive imaging modalities. It involves examination of - both thyrocervical trunks, both internal mammary arteries and both carotids, with occasional selective superior thyroid artery catheterisation. Vascular parathyroid adenomas appear as a persistent oval or round ‘stain’ on angiography . Serious complications such as contrast-induced renal failure, embolisation and neurological damage have limited its utility . Selective venous sampling for PTH can allow accurate localisation of adenomas but an experienced interventional radiologist is vital for success. The venous drainage of the lesion is established when there is a twofold drop in the PTH betw een the sampled blood and the serum PTH. The sensitiv - ity is reported to be 80% and is equally e ff ective in localising cervical and mediastinal adenomas. However, the false-positive to reoperative rate of between 6% and 18% limits its utility cases.

(b) Figure 56.4 (a, b) Four-dimensional computed tomography scanning demonstrating a right inferior parathyroid adenoma (arrows).

Surgical management The mainstay of treatment for PHPT is surgery , addressing the underlying aetiology and allowing not only resolution of biochemical abnormalities but also sustained improvements in end-organ damage. Traditionally a bilateral cervical explora tion was performed with reported cure rates of 95–98%. With improvements in preoperative radiological localisation, a more minimally invasive approach has been developed and widely adopted (Figure 56.5). All symptomatic patients should be o ff ered surgery . An expert panel published recommendations on which asymp tomatic patients should be considered for surgical intervention (Table 56.2). Guidelines from the American Association of Endocrine Surgeons have more liberal indications for surgery . These included patients with cognitive or psy chiatric symp toms attributable to PHPT , cardiovascular disease (excluding hypertension) and more non-specific symptoms, such as muscle weakness, impaired functional capacity and abnormal sleep patter ns. When criteria have been met and where a single ade noma has been confidently identified by radiological means, a /uni25CF /uni25CF /uni25CF /uni25CF versely , where there is discordant imaging or where imaging fails to identify any parathyroid abnormalities, then a bilateral neck exploration and a three-and-a-half-gland parathyroidec - tomy or a four -gland parathyroidectomy and autotransplanta - tion should be performed. Consent for a parathyroidectomy must include the - possibility of recurrent laryngeal nerve damage (risk <1%), permanent hypoparathyroidism (requiring lifelong calcium and vitamin D supplementation; risk 0.5%) and persistent (5%) or recurrent hyperparathyroidism. Persistent disease is defined as an elevated serum calcium within 6 weeks of surgical intervention and recurrent disease is defined as an increase in - calcium levels after 6 months but with an intervening period of normocalcaemia. Minimally invasive (focused) parathyroidectomy - Minimally invasive approaches are based on the principle that over 80% of individuals with PHPT have a single adenoma. Although there is no strict definition of the procedure, it commonly refers to the removal of a localised abnormal - parathyroid gland through an incision less than 3 /uni00A0 cm in length (Figure 56.6). The term encompasses open approaches (central and lateral incisions) and video-assisted and radio- guided parathyroidectomies. A number of randomised studies have shown that the focused approach has similar cure rates to

TABLE 56.2 Consensus guidelines for surgical intervention in asymptomatic primary hyperparathyroidism. Measurement of 0.25 /uni00A0 mmol/L (1.0 /uni00A0 mg/dL) above the upper limit serum calcium of normal Skeletal BMD by DEXA; T score –2.5 at lumbar spine, total hip, femoral neck or distal one- third of radius Vertebral fracture Renal Creatinine

clearance <60 /uni00A0 mL/min 24-hour urinary calcium >10 /uni00A0 mmol/dL (>400 /uni00A0 mL/day) or increased risk of stone formation by risk analysis Age <50 years BMD, bone mineral density; DEXA, bone densitometry. Adapted from Bilezikian et al . (2014). Concordant Discordant MIBI and US imaging imaging Pre-op marking 4D CT with US Pre-op 4 gland MIP marking with exploration US and MIP Figure 56.5 Localisation paradigm and management strategies. 4D /uni00A0 CT, four-dimensional

computed tomography; MIBI, 2-methoxy-2 methylpropylisonitrile; MIP , minimally invasive parathyroidectomy; US, ultrasonography. (a) (b)

Figure 56.6 (a) Minimally invasive parathyroidectomy through a lateral approach; (b) the excised parathyroid adenoma.

hypocalcaemia, shorter operating times, potentially less pain and better cosmesis. The need to convert from a focused to a cervical explora tion may be guided by the use of intraoperative PTH mea surements. Routine use is, however, controversial owing to high false-positive and false-negative rates. The basic concept is that the half-life of circulating PTH is 3–5 minutes and there should therefore be a significant dr op detected in the plasma PTH following resection of a single adenoma. If no such drop is detected, then multigland disease may be sus pected and conversion to a bilateral neck exploration should be considered. The Miami criteria were developed to determine the extent of resection. A drop in the PTH into the normal range and to less than half the maximum preoperative PTH at 10 /uni00A0 minutes appears to accurately predict single-gland disease (Figure 56.7). Bilateral neck exploration A traditional cervical neck exploration is required where imaging is negative or discordant, in MEN (type 1 or type 2A) or in lithium-induced PHPT . A transverse collar (Kocher's) incision is made and the subplatysmal plane developed. The deep cervical fascia is divided between the strap muscles and these are retracted. The thyroid lobes are mobilised and the middle thyroid vein may be divided when present. Identification of the recurrent laryngeal nerve and the middle thyroid artery allows a starting point for a systematic exploration (see Chapter 55). All four glands are identified. Three and a half glands ar e resected, with half of a vascularised parathyroid left in situ . The other half of the gland should be sent for frozen section to confirm the presence of parathyroid tissue (Figure 56.8). Ideally the most normal-appearing parathyroid is left in situ . With this caveat in mind, where possible an inferior gland should be left. It is marked with a non-absorbable suture to aid identification in the presence of recurrent disease, where resection can be achieved without increasing the risk of damage to the recurrent laryngeal nerve. Alternatively , all four glands can be resected and a forearm autotransplant created. Small pieces of parathyroid are sutured into pockets created in the brachioradialis muscle. Cure rates and rates of persistent and recurrent disease appear to be similar, regardless of the Emil Theodor Kocher , 1841–1917, surgeon, Berne, Switzerland, awarded the Nobel Prize in Physiology or Medicine in 1909 for his research on the thyroid. - - - type of procedure used. However, in recurrent disease it can be di ffi cult to identify the location of the recurrent tissue when an autotransplant is performed. Thymectomy and resection of mediastinal adenomas The incidence of clinically significant supernumerary glands is increased in patients with multigland disease or those with hereditary syndromes. A thymectomy should be routinely undertaken for patients with MEN1 - associated PHPT or in secondary hyperparathyroidism. A cervical thymectomy is performed by dissecting close to the thymic capsule, exploring the cervical part of the gland. The mediastinal part of the gland can be removed by gentle upwards traction, with ligation of the veins draining into the innominate vein. The end of the

120 100 80 60 40 20 % PTH remaining 0 0 5 10 15 Time (min) Figure 56.7 Miami criteria for intraoperative parathyroid hormone (PTH) measurement. Drop of PTH into the normal range and less than half the maximum value at 10 minutes postresection. (b) Figure 56.8 Parathyroidectomy with exposure of the left superior and inferior parathyroid glands (white arrows) in situ (a) and left superior gland mobilised on its vascular pedicle (b) .

sternotomy is not required where a prophylactic thymectomy is being performed. Mediastinal adenomas are rare, accounting for less than 1% of all parathyroid adenomas. They will be typically identi fied on preoperative imaging. Resection can be achieved either b y an open sternotomy or increasingly by a thoracoscopic approach. A minimally invasive approach can be particularly e ff ective where the abnormal gland lies immediately deep to the mediastinal pleura. It can confer significant advantages in length of hospital stay and complication rates.

Revision #1
Created 2025-12-31 15:21:04 UTC by Omar Ayman
Updated 2025-12-31 15:21:04 UTC by Omar Ayman