Single-Port Transaxillary Robotic Parathyroidectomy

11

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Surgical steps

1. *Preoperative considerations*
2. *Informed consent*
3. *Patient positioning*
4. *Surgical equipment*
5. *Transaxillary access to the neck*
6. *Preparation of the robotic field*
7. *Robotic surgery*
8. *Postoperative care and follow-up*
9. *Surgical complications*
10. *Mentoring and proctorship*

11.1 Preoperative Considerations

As with all surgical operations, patient selection is paramount. Prior to offering the approach to a patient, a multidisciplinary evaluation with an endocrinologist and radiologist is mandatory. This is to confirm the presence of primary hyperparathyroidism (pHPT), localize the adenoma, and exclude conditions such as vitamin D deficiency or familial hypocalciuric hypercalcemia (FHH) which do not require surgical intervention [1].

Single-port transaxillary robotic parathyroidectomy (RP) constitutes an advanced remote-access targeted parathyroidectomy approach. When considering the indications, the approach is an option when a single adenoma has been clearly identified and there is concordance between different imaging modalities. To minimize the risk of failure and need for revision surgery, we advocate triple modality concordance using ultrasonography, sestamibi scintigraphy, and single-photon emission computed tomography (SPECT-CT).

Adenoma size is not a limitation nor is adenoma location. With the exception of giant parathyroid adenomas that are exquisitely rare, parathyroid adenomas are usually relatively small [2]. Ectopic parathyroid adenomas located in the mediastinum and retropharyngeal space have also been successfully removed using the robotic technique. However, access to these locations is not the same (thoracoscopic and transoral routes, respectively) and beyond the scope of this chapter [3–7].

Other important considerations prior to offering RP include body habitus, comorbidities, and patient psyche. A list of contraindications to RP is presented in Table 11.1.

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The ideal RP patient would be slim with a preoperatively localized parathyroid adenoma. Individuals with a predisposition to hypertrophic scarring and keloid formation are ideal candidates as the avoidance of a neck scar is particularly desirable [8].

Table 11.1 Contraindications to single-port transaxillary robotic parathyroidectomy

Obesity (BMI >30 kgm^{-2})
Large ipsilateral goiter
Previous surgery to the neck
Previous radiotherapy to the neck
Important co-comorbidity (ASA>2)
Suspicion of parathyroid carcinoma
Ipsilateral acromioclavicular osteoarthritis

11.2 Informed Consent

Informed consent is undertaken by the attending surgeon. RP may be offered as an alternative to the conventional cervical approach, and both options should be discussed with the patient.

The risks associated with RP are the same as for conventional parathyroidectomy with regard to the recurrent laryngeal nerve (RLN), infection, hematoma, seroma, persistent hyperparathyroidism, and need for revision surgery. The literature does not support an increased infection rate with RP compared to cervical parathyroidectomy [9].

Additional points that should be explained to the patient include the fact that there will still be a scar though this will be concealed in the axilla. Moreover, it is very likely that they will experience dysesthesia on the chest over the area that the subcutaneous flap has been raised. This almost always resolves though may take several months. Pain is not a particular problem with RP [9, 10]. The patient should also be made aware of the risk of brachial plexus neurapraxia. This is rare and becomes almost a "theoretical" risk when the ipsilateral arm is placed in the "extended salute" position (see Sect. 3, "Patient Positioning").

With regard to the latter risks (axillary scar, dysesthesia on chest, and potential for brachial plexus neurapraxia) and the prolonged operative time, it should be made clear to the patient that these are specific to RP and not associated with conventional parathyroidectomy so that they can subsequently make an informed decision. The inpatient stay and time off work are similar to the conventional open technique [9, 11].

11.3 Patient Positioning

It is important to position the patient's ipsilateral arm when they are awake in order to ensure comfort and thus minimize the risk of traction on the brachial plexus (and associated neurapraxia) [12]. The ipsilateral arm must be free of identification bracelets, lines, blood pressure cuffs, or EKG leads. Arm positioning involves the back of the patient's hand touching the central portion of the forehead, in an "extended salute" position (Fig. 11.1). This has been shown to minimize the risk of brachial plexus neurapraxia [13].

A 5–6 cm axillary incision is also marked at this point as in our experience this is the optimal way to plan where to place the incision to prevent subsequent migration. The incision may need to be extended superiorly in a curvilinear fashion so that it sits in a natural skin crease. This reduces tension and a tendency toward hypertrophic and pigmented scarring. Laterality (side of surgery) is indicated by a skin marker (arrow).

Following this, the anesthesiologist intubates the patient and ventilates them via a transoral endotracheal tube with electrodes (NIM EMG Endotracheal Tube, Medtronic, Inc., Jacksonville, FL). The correct positioning of the NIM EMG endotracheal tube with the electrodes at the level of the glottis is confirmed by direct laryngoscopy. Visualization of the electromyographic waveform on the nerve integrity monitor (NIM) following insertion of the stimulator and earth leads serves as additional confirmation. An extended tip of the NIM must be available due to the long distance between the axillary incision and neck. At induction, the patient is routinely administered intravenously 1.2 g co-amoxiclav and 4 mg dexamethasone.

Contrary to conventional parathyroid surgery, a shoulder roll is not placed under the shoulders as this leads to neck extension moving the parathyroid adenoma away from the robotic instruments. Instead, a pillow is placed under the patient's head and shoulders to provide adequate and comfortable support in a subtle "sniffing the morning air" position. The head of the table is then dropped to about 20° to widen the angle between the arm and chest.

Fig. 11.1 The "extended salute" position for single-port transaxillary robotic parathyroidectomy. By adjusting the position of the ipsilateral arm with the patient awake to assess for comfort, the risk of traction injury to the brachial plexus is minimized. Doing so and marking the incision immediately prior to surgery constitute vital components of preoperative planning. The laterality is pre-marked with an *arrow* as is the external jugular vein, sternal head of sternocleidomastoid muscle, parathyroid adenoma location, and the 5–6 cm axillary incision. This is rechecked once the patient is positioned on the operating table as in our experience this is the optimal way to plan where to place the incision to prevent subsequent migration. Note extensive scaring on the chest from chickenpox (anteriorly) and right lateral minithoracotomy hypertrophic scar from previous bullectomy to treat pneumothorax. This is a patient who had valid reasons for wanting to avoid a visible neck scar and seeking a transaxillary approach for his parathyroidectomy

11.4 Surgical Equipment

The surgical equipment consists of the non-robotic trays (used for the single-port transaxillary access) and the robotic instruments. These are illustrated in Figs. 11.2, 11.3, 11.4, 11.5, 11.6, and 11.7.

Fig. 11.2 Non-robotic instruments used for establishing the single-port transaxillary access. These include a Bovie (monopolar electrocautery) with a long extension and insulated tip, Harmonic scalpel (Ethicon Endo-Surgery, Inc., Johnson & Johnson, Cincinnati, OH), pledgets (Teleflex® Inc., NC), and Langenbeck retractors

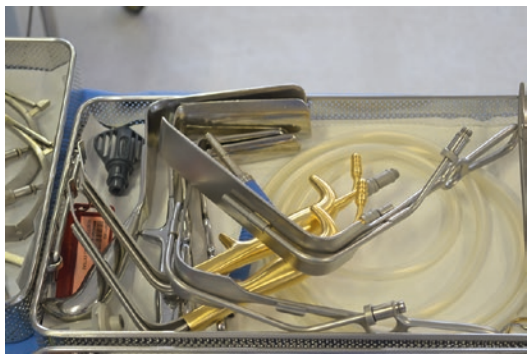

Fig. 11.3 Self-illuminating retractor used for raising the subcutaneous flap for single-port transaxillary access to the neck

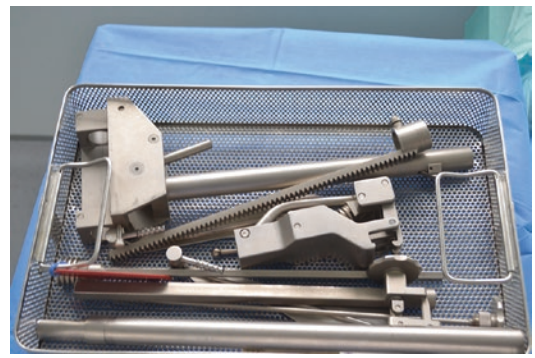

Fig. 11.4 The Modena surgical modular retractor (CEATEC® Medizintechnik) is introduced once the flap has been raised and prior to docking the da Vinci robot (Intuitive Surgical, Sunnyvale, CA). It incorporates a suction tube to its blade to prevent fogging of the robotic dual-channel endoscope intraoperatively

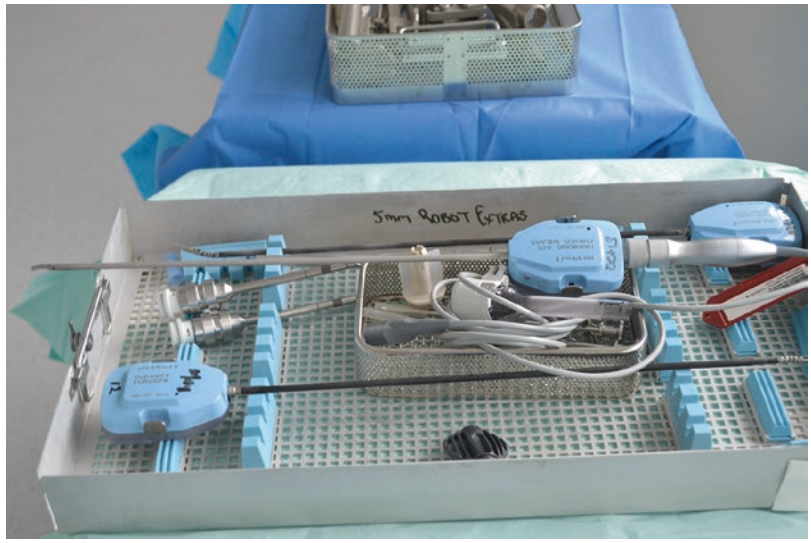

Fig. 11.5 The three robotic arms used: Harmonic ACE curved shears, DeBakey forceps, and Maryland dissector used in single-port transaxillary robotic parathyroidectomy. The fourth assistant arm holds the 8 mm ProGrasp which serves mainly for retraction of the ipsilateral thyroid lobe (see Fig. 11.17). Following insertion into their trochars, all robotic arms and camera are inserted through the axillary incision

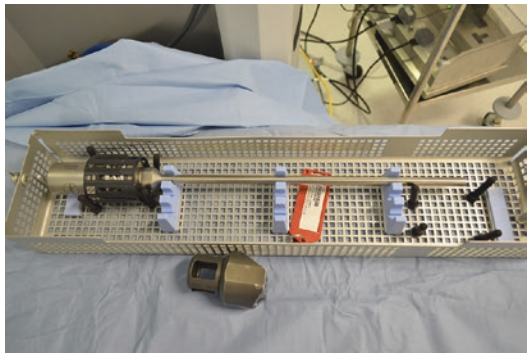

Fig. 11.6 A 30° down, 12 mm dual-channel endoscope is used. The endoscope and all robotic arms are inserted through the axillary incision

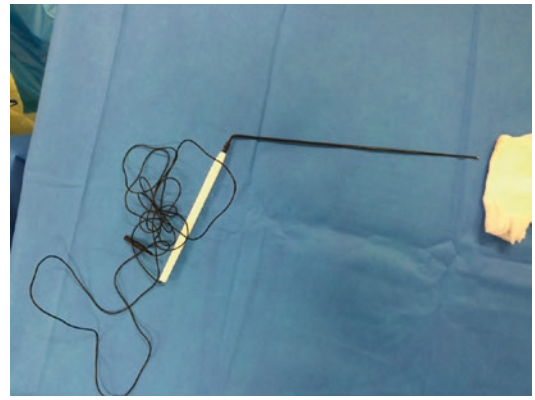

Fig. 11.7 The extended tip of the nerve integrity monitor required during robotic dissection for stimulation of the recurrent laryngeal nerve due to the long distance between the axillary incision and neck

11.5 Transaxillary Access to the Neck

This follows patient positioning (Fig. 11.8), sterilization, and draping. It provides access to the operative field and precedes the robotic part of the operation. A step-by-step narrative is provided in Figs. 11.9, 11.10, 11.11, 11.12, 11.13, 11.14, and 11.15.

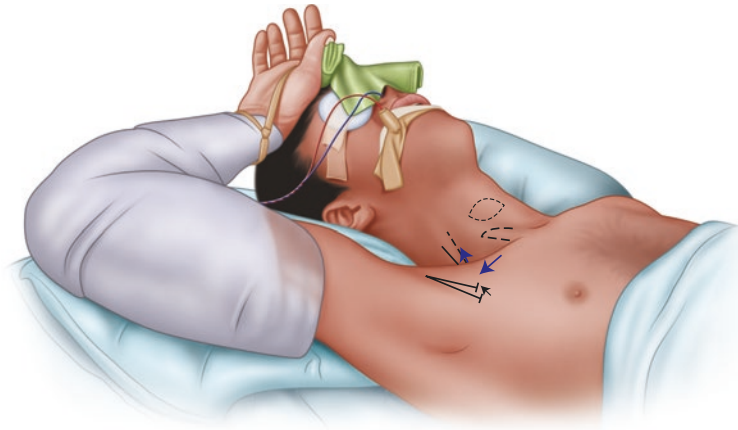

Fig. 11.8 The "extended salute" position for right single-port transaxillary robotic parathyroidectomy (laterality pre-marked with *arrow*). This position shortens the distance between the incision site and parathyroid adenoma by elevating and externally rotating the clavicle while protecting the brachial plexus from traction. This is a modification to Chung's method for transaxillary robotic thyroidectomy where the arm is fully extended over the head [14]. We advise against the fully extended arm position as this puts the brachial plexus at risk through traction. We have had no such problems since modifying Chung's method of arm positioning. Adjusting the position of the ipsilateral arm with the patient awake to assess for comfort and marking the incision immediately prior to surgery constitute vital components of preoperative planning. The 5–6 cm axillary incision has been pre-marked and rechecked once the patient is positioned on the operating table as in our experience this is the optimal way to plan where to place the incision to prevent subsequent migration. Note the NIM EMG endotracheal tube, eye protection, and special arm rest to support the arm which is abducted and flexed with the forearm being pronated so that the back of the hand rests on the central portion of the forehead. A Velcro coin is attached to the hand and forehead to maintain the position

Fig. 11.9 The axillary incision. Note the sterile field includes the neck, anterior thorax, and ipsilateral axilla. EKG leads are placed on the back so as not to interfere with the sterile field

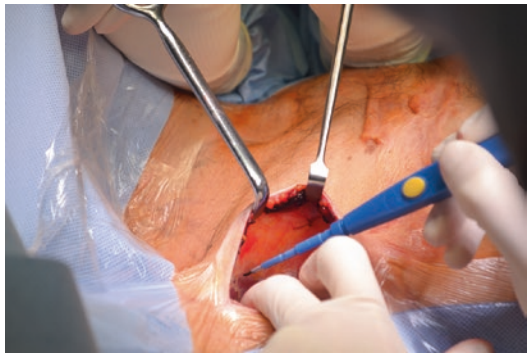

Fig. 11.10 Following the axillary incision, a subcutaneous flap is raised superficial to the clavipectoral fascia. The superior and inferior points of the axillary incision are extended to the thyroid cartilage and sternal notch, respectively. The resulting shape of the flap is that of a trapezoid. In taller patients, if the distance from the axilla to the sternal notch exceeds the limit of the instruments, the robot can be docked in earlier to perform the last (most distal) part of the subcutaneous flap raising. The technique for entering the neck is identical to the one described below but is performed robotically. This modification expands the range of patients to whom single-port transaxillary robotic parathyroidectomy can be offered [15]

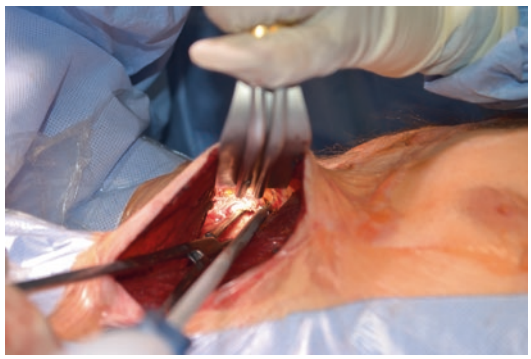

Fig. 11.11 Once the subcutaneous flap is raised, dissection is continued above the pectoralis major and over the clavicle until the sternal and clavicular heads of the sternocleidomastoid muscle are reached

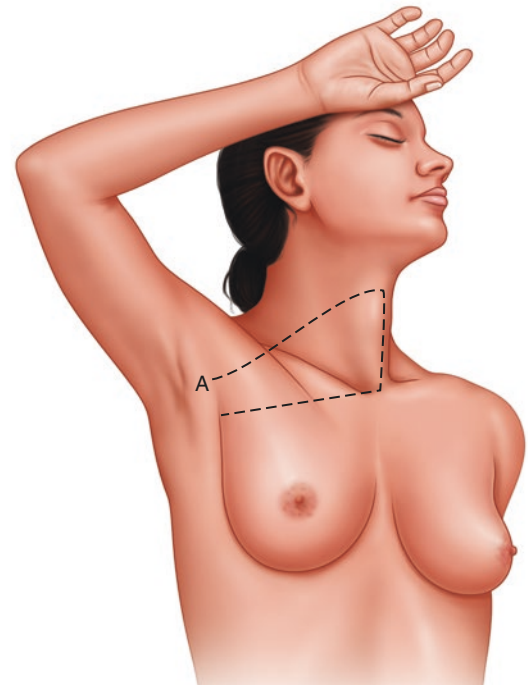

Fig. 11.12 Schematic representation of the incision and anatomical boundaries of the subcutaneous flap needed for right single-port transaxillary robotic parathyroidectomy. The superior and inferior points of the axillary incision are extended to the thyroid cartilage and sternal notch, respectively, resulting in a trapezoid-shaped flap as shown

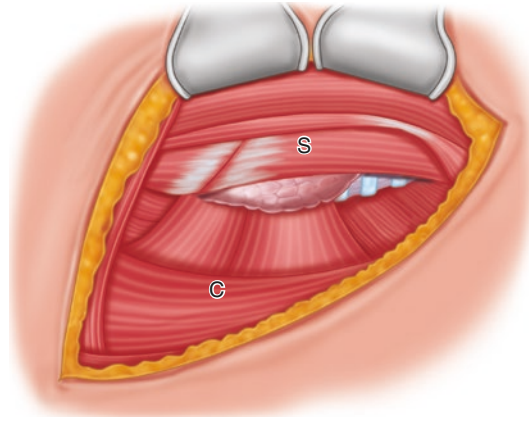

Fig. 11.13 Close-up view of the sternal (S) and clavicular (C) heads of the sternocleidomastoid muscle and the natural dehiscence between the two. The surgical planes are then developed as in a standard parathyroidectomy exposing the ipsilateral internal jugular vein, common carotid artery, and omohyoid and sternohyoid muscles (see Fig. 11.20)

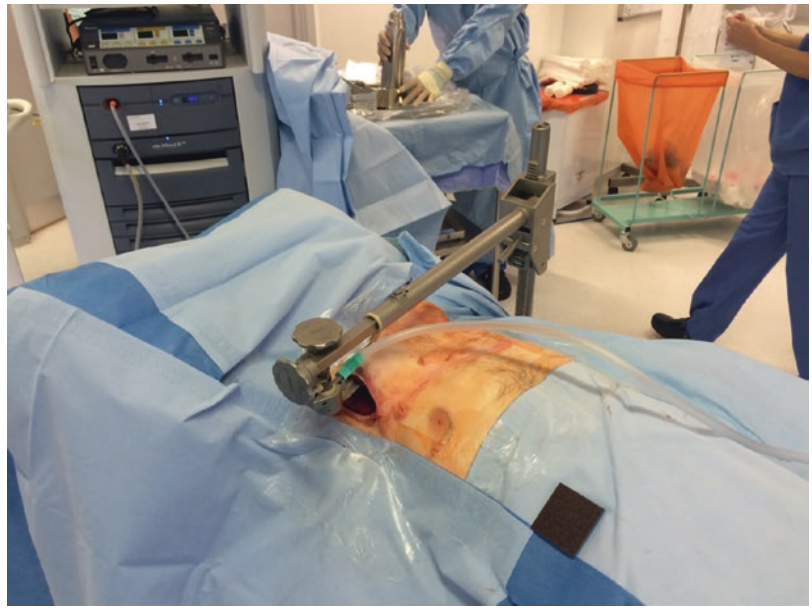

Fig. 11.14 The Modena retractor in situ. Once placed, it is important to connect its port to a suction tube so as to prevent fogging of the robotic dual-channel endoscope once it is inserted

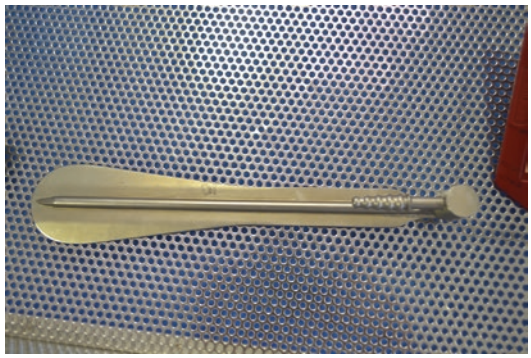

Fig. 11.15 The Modena retractor blade. This is placed under the flap and strap muscles to retract them and create sufficient working space for the robotic arms to be introduced and for them to be able to move freely without clashing. No gas insufflation is required. Once this is positioned and adequate visualization and space confirmed, the da Vinci robot is docked

11.6 Preparation of the Robotic Field

The setup of the operating room (OR) for right single-port transaxillary robotic parathyroidectomy is schematically shown in Fig. 11.16 and the introduction and orientation of the robotic arms and 3D endoscope through the axillary incision explained in Fig. 11.17.

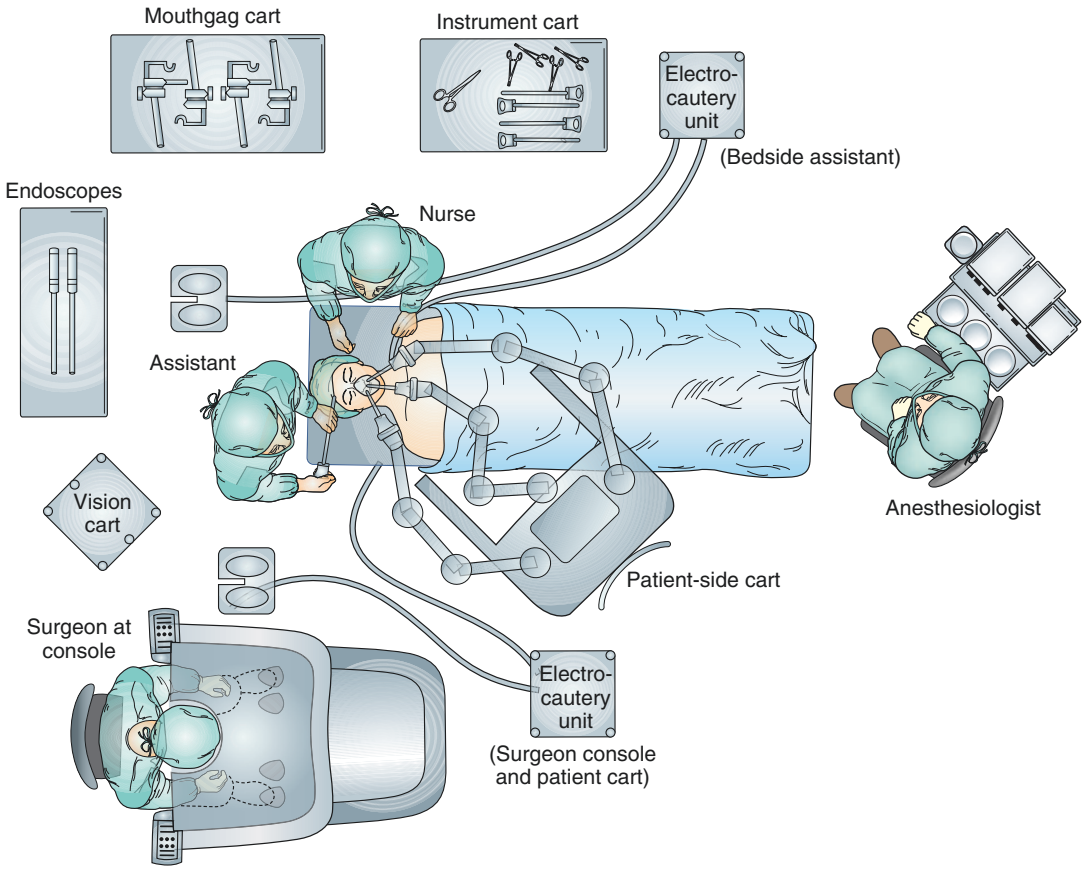

Fig. 11.16 Operating room configuration for right single-port transaxillary robotic parathyroidectomy. Note the cart is docked at right angles to the operating table on the contralateral side to the adenoma

Fig. 11.17 All three robotic arms are placed through the single axillary incision. The 30° down 12 mm stereoscopic endoscope is placed at an angle of 220° and is inserted low laterally extending high and upward medially toward the thyroid gland. The fourth arm can then be placed under the endoscope which is used to retract the thyroid lobe medially. Finally, the first and third arms are positioned which carry the instruments for dissection and hemostasis. The fourth assistant arm holds the 8 mm ProGrasp, while the first and third arms have a combination of 5 mm Maryland, DeBakey, and Harmonic shears

11.7 Robotic Surgery

Following docking of the da Vinci surgical robot, the instruments are placed through their corresponding ports in the respective robotic arms. Initially, provided the robotic surgeon is right-handed, the fenestrated bipolar forceps is placed in the right (first) robotic arm and the 5 mm Maryland dissector in the left (second) one. In the third robotic arm, the DeBakey forceps is placed which can be interchanged with the clutch on the robotic platform with the fenestrated bipolar forceps. Once the parathyroid adenoma and its pedicle are delineated, this can be replaced with the Harmonic shears so that the robotic surgeon has a combination of 5 mm Maryland, DeBakey, and Harmonic shears for dissection and hemostasis. In the fourth arm, the 8 mm ProGrasp is inserted and placed under the endoscope to contralaterally retract the thyroid lobe.

The different stages of the robotic dissection are presented in a step-by-step narrative in Figs. 11.18, 11.19, 11.20, 11.21, 11.22, 11.23, and 11.24.

Following delivery of the parathyroid adenoma, this is sent for histopathological analysis. We do not routinely use intraoperative quick PTH (iQPTH) monitoring as all RP cases in our endocrine surgery tertiary referral center undergo an intensive multidisciplinary preoperative workup and only patients with triple modality concordance are considered for this approach. This is precisely to minimize the risk of persistent hyperparathyroidism and subsequent need for revision surgery (see Sect. 1, “Preoperative Considerations”). We do however use iQPTH routinely if no triple modality concordance exists or there is any other doubt about adenoma location or the presence of parathyroid hyperplasia, though, as already discussed, such patients would not constitute candidates for robotic surgery. In the presence of preoperative triple modality concordance, iQPTH monitoring can be safely omitted when performing focused parathyroidectomy for most cases of pHPT [17, 18].

As with all parathyroid surgery, hemostasis should be meticulous. The anesthesiologist is asked to bring the blood pressure up to normal and a reversed Trendelenburg position and Valsalva maneuver applied. Any remaining bleeding points

are addressed at this stage to ensure hemostasis. As in conventional parathyroid surgery, no drain is applied. We have not found this to be a problem.

Following hemostasis, the da Vinci robot is withdrawn and 2-layer closure completed with 4-0 subcuticular Vicryl Rapide sutures (Ethicon Products, Inc., Johnson & Johnson, Cincinnati, OH) followed by application of Dermabond (Ethicon Products, Inc., Johnson & Johnson, Cincinnati, OH) tissue glue on the wound (Fig. 11.25). An anterior chest wall compression dressing is applied overnight (Fig. 11.26).

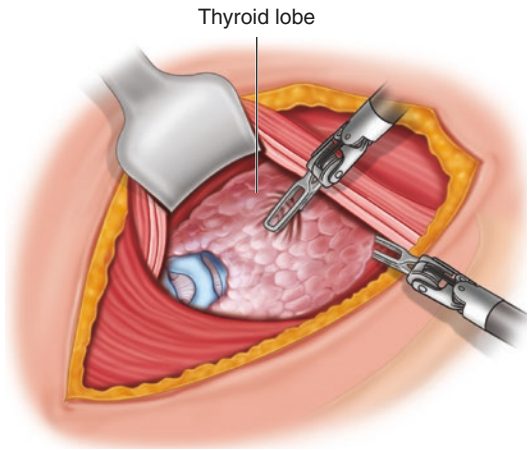

Fig. 11.18 Entering the natural dehiscence between the sternal and clavicular heads of the sternocleidomastoid muscle. As the flap and strap muscles are retracted by the Modena retractor, the first structure to encounter is the ipsilateral thyroid lobe

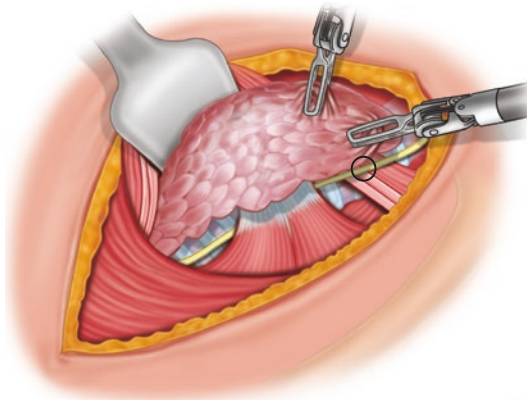

Fig. 11.19 The thyroid lobe is retracted medially and the recurrent laryngeal nerve (*circled*) identified in the tracheoesophageal groove

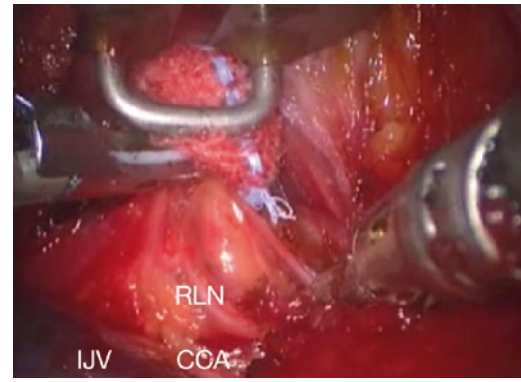

Fig. 11.20 The great vessels of the neck, the common carotid artery (CCA), and the internal jugular vein (IJV) are also identified while keeping into view the recurrent laryngeal nerve (RLN)

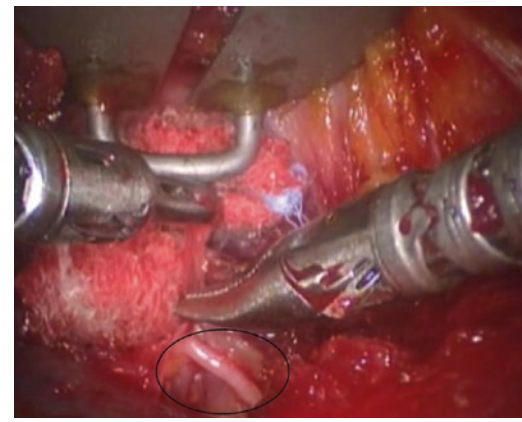

Fig. 11.21 Following identification of all relevant neurovascular structures, the recurrent laryngeal nerve (*circled*) is carefully dissected, stimulated, and subsequently gently displaced laterally out of the operative field and protected with a pledget

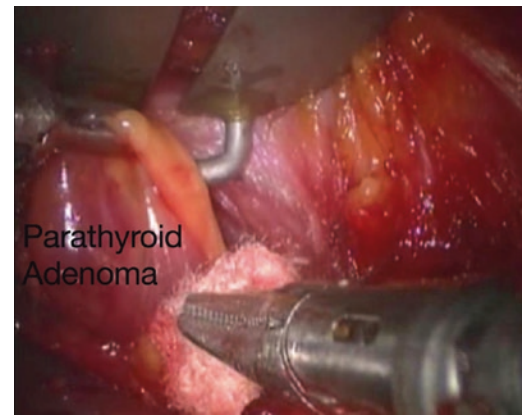

Fig. 11.22 Next, the parathyroid adenoma is identified posterior to the thyroid and bluntly dissected with a pledget

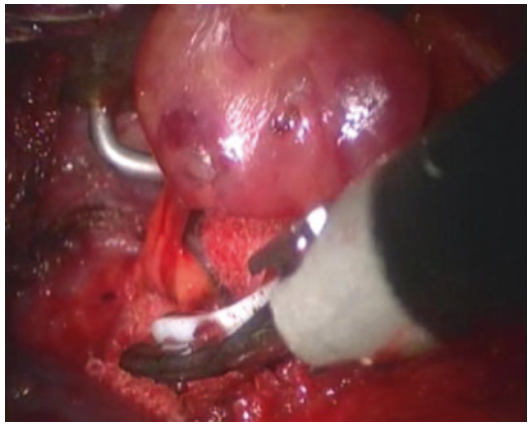

Fig. 11.23 Following blunt dissection of the parathyroid adenoma, its vascular pedicle is delineated. At this point, the Harmonic shears is introduced

Fig. 11.25 Following hemostasis, the da Vinci robot is withdrawn and 2-layer closure completed with 4-0 subcuticular Vicryl sutures followed by application of Dermabond tissue glue on the wound. Note the ecchymosis over the distal flap just superior to the axillary incision. This commonly appears due to the prolonged retraction and resolves after about 2 week following surgery

Fig. 11.24 The Harmonic shears is used to ligate and divide the vascular pedicle. Prior to doing so, it is vital to reconfirm the position of the recurrent laryngeal nerve, protect it again with a pledget, and keep the Harmonic shears at a clear distance from it, as illustrated, to prevent nerve damage from lateral thermal spread [16]. Subsequently, the parathyroid adenoma can be delivered through the axillary incision by the assistant surgeon

Fig. 11.26 Following wound closure, the ipsilateral arm is brought back to the neutral position, and an anterior chest wall compression dressing is applied overnight

11.8 Postoperative Care and Follow-Up

Patients are discharged the following morning once corrected calcium and PTH levels have been checked and confirmed to be normal (<24 h hospital stay). They are advised to wear a sports bra or vest for 2 weeks to provide light compression to the anterior chest wall. Antibiotics (co-amoxiclav 625 mg three times a day) are routinely given for 7 days and analgesia (acetaminophen 1 g four times a day for 7 days) as required. Regular follow-up at 2 weeks, 3, 6, 12, 18, and 24 months allows prospective long-term evaluation.

11.9 Surgical Complications

As discussed, the risks associated with RP are the same as for conventional parathyroidectomy with regard to the recurrent laryngeal nerve (RLN), infection, hematoma, seroma, persistent hyperparathyroidism, and need for revision surgery. Thus, preventing and managing those complications involves the same measures as in conventional parathyroid surgery. The only exception relates to the prevention of hematoma and seroma where following wound closure, an anterior chest wall compression dressing is applied overnight. The next morning, this is removed, and the patient is advised to wear a sports bra or vest for 2 weeks to provide light compression to the anterior chest wall.

This section will address those complications that relate specifically to RP. These are dysesthesia on the chest over the area of the subcutaneous flap and brachial plexus neurapraxia.

Regarding dysesthesia over the chest wall, it is important to mention this to the patient before surgery so that they expect it. As a matter of fact, this is not a complication but a natural occurrence following subcutaneous flap elevation. All patients will experience this to a certain extent. It is equally important to explain to the patient that it almost always resolves though can take several months to do so. Pain is not a particular problem with RP [9, 10].

The other risk is brachial plexus neurapraxia. Patients need to be also made aware of this, but at the same time, they need to be explained so that this is exquisitely rare, provided the correct preventative measures have been employed. These are described below.

The key to preventing brachial plexus neurapraxia is by placing the arm in the "correct" position and maintaining this for the duration of the operation. The reason for this is that the mechanism underlining this complication involves hyperextension of the brachial plexus. By "correct" we mean a position where the ipsilateral arm is comfortable for the patient while ensuring optimal transaxillary access to the neck. The only way to achieve this is by positioning the patient's arm when they are awake in order to assess for comfort (and thus prevent hyperextension of the brachial plexus) [12]. The position we advise for the arm is the "extended salute" position described in detail in Fig. 11.1. This position shortens the distance between the incision site and parathyroid adenoma by elevating and externally rotating the clavicle whilst protecting the brachial plexus from traction. A Velcro coin is attached to the hand and forehead to maintain the position during surgery.

As part of the routine postoperative check in the recovery room, it is vital not only to ask the patient for any abnormal sensation or weakness along their arm but also formally assess the neurovascular status of their upper limb. If any neurological deficit or shoulder stiffness is identified that has not resolved by the next morning, it is paramount to involve a physiotherapist at an early stage, i.e., prior to discharge to teach the patient what exercises to do daily and follow them up on an outpatient basis until full resolution occurs.

11.10 Mentoring and Proctorship

The most important influence on outcomes in parathyroid surgery is the experience and volume of the surgeon [19]. Thus, mentoring and proctorship are vital to optimize surgical results and minimize complications [20].

RP should only be undertaken by appropriately trained surgeons with sufficient experience in parathyroid surgery employed in high-volume institutions that possess the necessary equipment and access to technical support [11]. Finally, there needs to be a dedicated robotic nursing team too with the appropriate training and experience so as to enhance the performance of the robotic team.

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