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Article

Locoregional vs. General Anaesthesia for Minimally Invasive Video-Assisted Parathyroidectomy (MIVAP) Using Propensity Score Matching Analysis: A Feasibility Study

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Abstract: Focused parathyroidectomy is the preferred surgical method for treating primary hyperparathyroidism (pHPT) sustained by the pre-operatively well-localized parathyroid adenoma. We aimed to compare the effectiveness, safety, and short-term clinical outcome of minimally invasive video-assisted parathyroidectomy (MIVAP) in locoregional anaesthesia (LA) vs. general anaesthesia (GA) by means of propensity score matching (PSM) analysis. Retrospective research of patients who underwent MIVAP between January 2014 and December 2022 was carried out. Patients were divided into two groups based on the anaesthesiologic procedure (LA vs. GA). Overall, 553 patients underwent MIVAP. After PSM, 115 patients in the LA group and 230 patients in the GA group were included. MIVAP under LA was associated with shorter median operative time (16 vs. 35 min, $p < 0.001$), shorter median operative room occupation time (44 vs. 73 min, $p < 0.001$), and lesser median post-operative visual analogue scale pain, with comparable post-operative hospital stay and complication rate. MIVAP under LA is a safe and feasible procedure with significant advantages over GA in terms of post-operative pain and operative room occupation time. This last step can finally result in more efficient utilisation of the operative room and the health care system's resources.

Keywords: primary hyperparathyroidism; focused parathyroidectomy; minimally invasive video-assisted parathyroidectomy (MIVAP); locoregional anaesthesia; cost analysis

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1. Introduction

Calculating the exact operating room expense is not simple in our country [1,2], especially when considering parathyroid surgery. One single minute of operating room time may be affected by several factors [3]: the country where the surgery takes place, the type of surgical procedure, and the additional necessary resources. Moreover, further specific variables may complicate parathyroid surgery, including localisation of pathologic parathyroid gland [4], visualisation of recurrent laryngeal nerve, and intraoperative PTH (ioPTH) monitoring.

Primary hyperparathyroidism (pHPT) is the third most frequent endocrine disorder, with a prevalence of 1–3% in Western countries [5,6], and surgery represents the only effective treatment [7,8]. This disease primarily afflicts individuals in their middle years, with the highest occurrence observed between the ages of 50 and 70. Nevertheless, the condition manifests itself from early childhood to adulthood. Women are disproportionately impacted compared to men, with a ratio of around 3:1 to 4:1 [8].

pHPT is often defined by high calcium levels in the blood and an elevated or abnormal level of parathyroid hormone (PTH) associated with hypercalcemia. There is minimal disagreement over the suitable treatment for primary pHPT in its typical presentation. If indications of hypercalcemia or excessive target involvement are present, surgery is and continues to be recommended [8].

Bilateral neck exploration (BNE) has been considered the gold standard for surgical treatment of pHPT for decades. BNE involves identifying at least four parathyroid glands and removing any highly abnormal glands based on the surgeon's assessment. Despite the outstanding outcomes achieved with BNE, challenges related to the intraoperative gland localisation, the potential damage to the surrounding structures, and the concurrent development of the pre-operative imaging techniques progressively led to the increase of less invasive approaches to parathyroidectomy. Since the early 1980s, researchers have investigated less invasive methods, like unilateral neck exploration, to reduce surgical stress and decrease the already low complication risk of parathyroidectomy.

The rationale for minimally invasive techniques application to parathyroidectomy is based on the presence of a solitary adenoma causing pHPT in the majority of patients (85%), thus leading to its potential identification and removal by means of a targeted and selective examination of the neck. In this context, minimally invasive video-assisted parathyroidectomy (MIVAP) [9] refers to the targeted excision of a single enlarged parathyroid gland that has been identified before the operation. MIVAP was initially documented by Miccoli et al. [9] in 1997. We included the procedure in our practice since 1998 [4]. Shortly after its initial description, this procedure became popular due to its easy replication in several surgical settings. The aforementioned advantages of this surgery have led to its worldwide recognition as the recommended treatment for pHPT. Nevertheless, it still allows for the possibility of an ipsilateral cervical exploration in the event of therapeutic failure [10,11]. Similarly, the ioPTH assay allowed intraoperatively verifying surgical treatment's effectiveness by providing a "biochemical" frozen section [4,12].

Locoregional anaesthesia (LA) utilisation during endoscopic operations has not been previously described. Nevertheless, the use of this technique in minimally invasive open procedures [13] is associated with established benefits, such as reduced post-operative discomfort, decreased occurrence of nausea and vomiting, faster recovery time, shorter hospital stay, and the ability to perform general anaesthesia (GA) surgery on elderly or high-risk patients [14,15]. On the other hand, such benefit has to be balanced with the up to 10% risk of conversion to GA procedure [16].

Unfortunately, to date, the experience of MIVAP under LA is limited worldwide. Thanks to extended previous experience in thyroid surgery [16], we introduced LA for parathyroidectomy in our clinical practice in selected patients.

This pilot study aims to evaluate the feasibility of LA over GA regarding operation time and post-operative complications for patients who underwent MIVAP.

2. Methods

We conducted a retrospective analysis (*per protocol analysis*) of data collected in a specialised database. The dataset contained information regarding patients who had undergone parathyroid surgery for pHPT from January 2014 to December 2022. The study was conducted at Fondazione Policlinico Universitario Agostino Gemelli IRCCS in Rome (Italy), a tertiary referral centre for endocrine and bariatric surgery. Data collection included demographic and pre-operative characteristics (age, sex as defined at birth, serum calcium and PTH level, comorbidities, clinical features), imaging results, intraoperative findings (operative time, intraoperative room time, intraoperative complications), ioPTH levels and post-operative results (serum calcium and PTH level, pain, complications as bleeding and/or laryngeal nerve palsy and/or hypocalcaemia, length of post-operative hospital stay and follow-up data). All data for this retrospective study have been institutionally collected in a prospectively designed database for endocrine neoplasm after approval by the Ethical Committee of our centre (Eurocrine® registry, ID 1416) for future retrospective studies. Informed consent for future retrospective studies was administrated to all patients at index operation. A formal evaluation by the Ethical Committee of this specific retrospective study was not requested, as it was unnecessary. This study complied with the principles defined in the Declaration of Helsinki. The follow-up, obtained through patient visits or phone contact, ended on 31 December 2023. Patients with concurrent thyroid surgery, multiglandular disease, parathyroid carcinoma, atypical parathyroid adenomas, bilateral neck exploration, operations for persistent/recurrent pHPT, surgical procedures different from focus parathyroidectomy (such as parathyroidectomies for double adenomas), surgical procedures different from MIVAP, patients affected by Multiple Endocrine Neoplasia types 1 and 2A, extra-cervical parathyroid localisation and secondary HPT were dismissed from the study.

2.1. Pre-Operative Evaluation

All patients received biochemical evaluation (serum calcium, phosphorus, ionised calcium, creatinine, albumin, basal calcitonin levels, 24-h urine calcium, phosphorus, creatinine, and fractionated metanephrines levels). Ultrasonography (US) and Tc-99m-sestaMIBI (tecnezio-99m-methoxyisobutylisonitrile) SPECT/CT scintigraphy were accomplished in all patients. PET-CT (using fluorocholine or 11C-methionine) was performed in the case of non-concordant pre-operative localisation exams. Pre-operative laryngoscopy was performed in all patients.

2.2. Definitions and Surgical Technique

The choice of type of anaesthesia is carried out only on patient compliance and not based on other parameters (such as clinical features or pre-operative localisation of the suspicious pathologic parathyroid gland). Therefore, the type of anaesthesia was chosen according to the patient's and surgeon's preference. In all cases, US evaluation was repeated before the surgical procedure by a surgeon with specific expertise in the US to confirm the indication of focused parathyroidectomy.

The surgical technique for MIVAP was previously published in detail [17].

The patient is lying on their back with the neck slightly extended. The surgical team comprises surgeons and two assistants, with one of the assistants specifically assigned to operate the endoscope. One of the most significant disadvantages of this procedure is the necessity of having at least three surgeons participating in the entire procedure. The monitor is placed at the head of the patient, in front of the surgeon, who is positioned on the patient's right side. The second monitor is typically placed in front of the assistant and on the patient's left side.

An incision measuring 1.5 cm is made in the skin, precisely between the cricoid cartilage and the sternal notch at the midpoint. The skin incision is often placed at a higher site than the standard method and can be modified according to the pre-operative ultrasonography findings. The cervical *linea alba* is incised to its maximum extent while being directly seen. The process is entirely free of the use of gas and does not include the use of any trocars. The thyroid lobe on the diagnosed side is medially retracted. In contrast, the strap muscles are laterally retracted using a small *Farabeuf* device, which facilitates the required space for the surgical procedure. Afterwards, the endoscope, which has a diameter of 5 mm and a 30° angle, is placed through the same skin incision along with the specialised tiny surgical instruments that measure 2 mm in diameter. One of the assistants holds the endoscope using both hands. The absence of any external support apparatus allows for adjusting and modifying the endoscope's placement if needed. Typically, the endoscope's tip is positioned towards the patient's head. However, if needed, it can also be reversed to allow for examination of the upper mediastinum. At this stage, the treatment closely resembles an open parathyroidectomy but is performed using an endoscope to provide visual guidance. Special attention is given to ensuring a precise, gentle, and minimally bloody dissection. Firstly, freeing the thyroid gland from the strap muscles is performed to obtain a distinct and comprehensive picture of the parathyroid gland sites. A thorough examination of the suspected abnormal gland is conducted after locating the inferior laryngeal nerve on the afflicted side, usually where it crosses the inferior thyroid artery. The parathyroid adenoma is excised using small spatulas and a spatula-shaped aspirator under endoscopic visualisation. The pedicle of the adenoma is fastened with titanium clips or ligated with a standard ligature or an energy device. After cutting the pedicle, the adenoma is extracted through the skin incision. Once the haemostasis has been verified, the strap muscles and the platysma are stitched together, and the small opening in the skin is closed using either a continuous subcuticular suture or a skin sealant. There is no left drainage.

LA was performed as follows [16]: after the patient was positioned on the operating table and vital signs were monitored, intravenous sedation was achieved by administering a 2 mg bolus of midazolam and a continuous infusion of remifentanil ranging from 0.003 to 0.014 gamma/kg/min. A cervical block was administered (Figure 1) using a combination of bupivacaine 0.25% and carbocaine 0.5% as a local anaesthetic. A 4-cm needle with a diameter of 23-gauge was placed at the middle point of the back edge of the sternocleidomastoid muscle on the afflicted side, with the tip pointing forward (Figure 2A). Initially, a 10-mL dose of the bupivacaine–carbocaine mixture was administered via injection (Figure 2B). The needle was subsequently oriented towards the midline, and an additional 5 mL of the anaesthetic mixture was administered while the needle was being removed (Figure 3A–C). The anaesthetic was injected at an intermediate level between the sternal notch and the cricoid cartilage in the midline along the line of the incision. Five mL was used (Figure 4A–C). Remifentanil administration was terminated immediately following the completion of the surgical procedure. A nasal cannula was used to administer supplemental oxygen at a rate of 3 L/min. After the procedure, acetaminophen 1000 mg (or tramadol 100 mg) and esomeprazole 40 mg were administered intravenously. Throughout the process, the patient remained conscious and capable of conversing with the surgical team.

ioPTH was performed in all patients [3]. Blood samples were taken in the following sequence: (1) before pre-incision; (2) during pre-excision (after dissection and immediately prior to clamping the blood supply of the suspicious gland); (3) 10 min after removing the adenoma; and (4) 20 min following adenoma resection [3]. In our previous study, we discovered that the most reliable indicators of surgical failure and ongoing disease (such as double adenoma or multiglandular disease) are a decrease in parathyroid hormone (PTH) of less than 50% within 20 min, a PTH level above the normal range at the 20-min mark, and a significant increase in PTH levels between the sample taken 20 min after gland removal compared to the sample taken 10 min after. Other authors referred to these standards as the “Rome criteria” [18]. Interpretation of ioPTH curves was based on the Roma criteria [3]. In the case of LA surgical procedures, only the first two blood samples were collected during the operation in the operating room. The remaining samples were taken when the patient was in the recovery room.

We did not perform an intraoperative frozen section of the specimen to confirm that a parathyroid abnormal tissue was excised.

The operations were conducted by either experienced endocrine surgeons or young endocrine surgeons who had been mentored [19]. More in detail, all LA procedures have been performed by the same experienced endocrine surgeon (M.R.).

The surgical procedure’s duration, or operating time, was determined as the time spent from the initial incision to the final suture. On the other hand, the duration of anaesthesia, also known as operating room time, was defined as the period between administering anaesthesia and the patient’s awakening. A definitive diagnosis was made based on the histopathological findings. Patients were discharged at least 24 h after the index operation if the calcium serum level was $\geq$8.0 mg/dL and symptoms were absent. Pain assessment was conducted using a visual analogue scale (VAS). The scale was comprised of a 10-cm line, with the phrase "no pain" on the left side (assigned a score of 0) and "worst pain imaginable" on the right side (assigned a score of 10). The patients were instructed to assess their pain by indicating its intensity on a line at three specific times: upon leaving the recovery room (approximately one hour after the surgery), referred to as POD0-value, on post-operative day 1 (as the average value for the entire day), and in the morning of post-operative day 2 (referred to as POD2 morning).

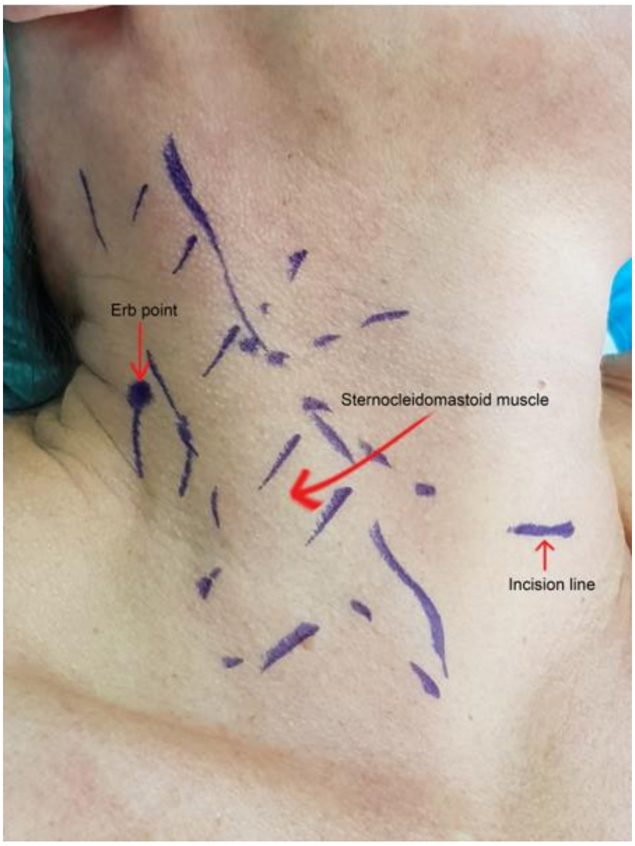

Figure 1. Anatomical points of the neck.

A B

Figure 2. (**A**,**B**): the first step is to insert the needle into the Erb point (**A**); after aspirating, a 10-mL bolus of the bupivacaine–carbocaine mixture is injected (**B**).

Figure 3. (**A**–**C**): in the second step, the needle was directed toward the midline, and an additional 5 mL of the anaesthetic mixture was used while the needle was withdrawn.

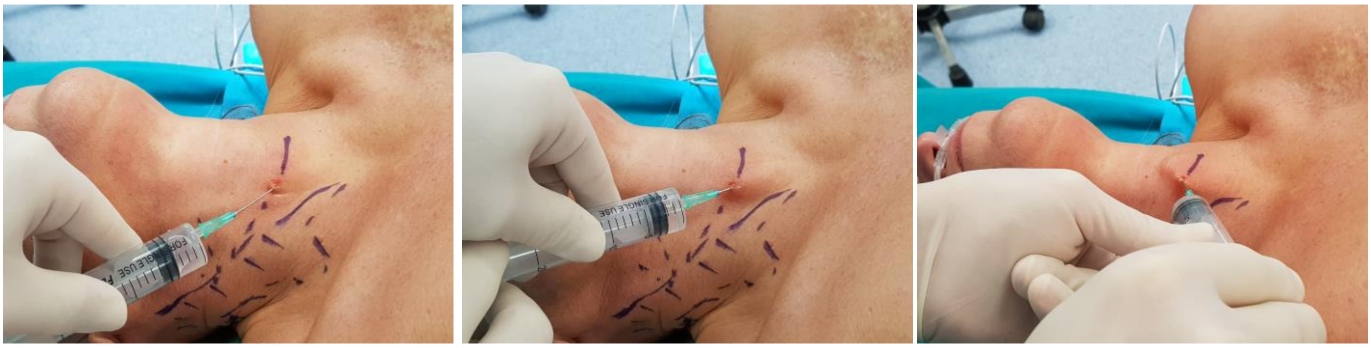

Figure 4. (**A**–**C**): in the last step, 5 mL of the anaesthetic was administered along the incision line at an intermediate level between the sternal notch and the cricoid cartilage in the midline.

Hypocalcaemia was defined as a blood calcium level below 8.0 mg/dL, irrespective of symptoms.

Definition of transient/permanent nerve palsy and transient/persistent hypoparathyroidism has been previously reported [20]. Biochemical cure and persistent/recurrent hyperparathyroidism were specified as follows: curative parathyroidectomy is defined as the achievement of normal calcium levels for a minimum of 6 months following surgery. Persistence of hyperparathyroidism is defined as the continued presence of high calcium levels within six months after the initial operation. Recurrence of hyperparathyroidism is defined as the reappearance of elevated calcium levels at or after six months [21].

2.3. Study Endpoints

The primary endpoint was to compare LA and GA in terms of the duration of the surgical procedure. The secondary endpoints were the evaluations of operative room time, post-operative pain, complications (such as bleeding, laryngeal nerve palsy, hypocalcaemia), and post-operative hospital stay.

2.4. Post-Operative Protocol

Serum PTH level was measured on POD1 (7 a.m.). The serum calcium level was assessed on post-operative day 1 (7 a.m.) and, if the hospital stay was extended, every morning (7 a.m.) after that until discharge. None of the patients received any pre-operative supplements. The rationale of supplementation with vitamin D and calcium after surgery was assessed by comparing pre- and post-operative levels of PTH and calcium and the occurrence of symptomatic hypocalcaemia.

All patients underwent post-operative laryngoscopy in POD1.

2.5. Statistical Analysis

The statistical analysis and Propensity Score Matching (PSM) was carried out using SPSS 22.0 software for Windows (SPSS Inc, Chicago, IL, USA). The dependent variable in the regression model of the propensity scores was the anaesthesiologic approach, which could be either locoregional or general. The propensity scores were matched using the "1:2 nearest neighbor" matching approach, with both groups discarded and a caliper of 0.2. A bivariate analysis compared the baseline characteristics and intraoperative and post-operative parameters. The normality of the distribution was evaluated using the Shapiro–Wilks test. We utilised a significance level of 5 per cent ($p < 0.05$). The chi-square test was employed to compare categorical variables. Continuous variables were reported as the mean value ± the standard deviation (range) if they followed a normal distribution. Otherwise, they were reported as the median value and interquartile range (IQR). We employed either the *t*-test or the Mann–Whitney test to compare continuous variables based on the data distributions.

3. Results

During the study period, 553 patients underwent MIVAP for pHPT sustained by (single) parathyroid adenoma. The patients were categorised into two groups based on the type of anaesthesia they received: 438 underwent MIVAP with general anaesthesia (GA) and 115 with local anaesthesia (LA). Following propensity score matching (PSM), the study population consisted of 345 patients, with 230 in the control group (GA) and 115 in the treatment group (LA). Table 1 illustrates the baseline characteristics, operation details, and post-operative outcomes. There were no significant differences between the groups in terms of their pre-operative demographic characteristics and their pre-operative levels of calcium and PTH in the blood serum. Delving deeper, median pre-operative PTH levels were 157.4 and 158 pg/mL for the LA group and the GA group, respectively. Similarly, median serum calcium levels were 11 and 10.9 mg/dL for the LA group and the GA group, respectively. Median operative time and median operative room time in the LA group were significantly shorter than in the GA group (16 vs. 35 min, $p < 0.001$, and 44 vs. 73 min, respectively, $p < 0.001$). No conversion from LA to GA was required. Median VAS values were lower in the LA group than in the GA group in POD0 and POD2 (0 vs. 1 $p < 0.001$, 0 vs. 1, $p = 0.002$, respectively). The median numbers of analgesic drugs requested during POD1 were lesser in the LA group compared to the GA group (0 vs. 1, $p = 0.01$). The two groups had no significant difference in the median length of post-operative hospital stay. No post-operative bleeding was observed. We registered only two cases of transient laryngeal nerve palsy, one in each group ($p = 0.251$); the laryngoscopy showed mild vocal fold hypomobility, and patients were treated with steroid therapy. No hypocalcaemia was registered. Histological analysis has been performed on the removed glands, revealing the presence of parathyroid adenoma in all 345 cases. The cure rates are comparable after a median of 19 months (18.5 vs. 19.0 for LA vs. GA, respectively, $p = 0.147$). No recurrences were observed during this period. No definitive laryngeal nerve palsy was reported.

Table 1. Data and statistical analysis.

	General Anaesthesia (n = 230)	Locoregional Anaesthesia (n = 115)	*p*-Value
Sex (Male/Female)	30 (13.1%)/200 (86.9%)	12 (20.8%)/103 (79.2%)	0.488
Age (years)	59 (52–69)	59 (50–71)	0.846
Pre-operative serum calcium level (mg/dL)	10.9 (10.5–11.5)	11.0 (10.4–11.5)	0.845

Table 1. *Cont.*

	General Anaesthesia (n = 230)	Locoregional Anaesthesia (n = 115)	*p*-Value
Pre-operative serum PTH level (pg/mL)	158.0 (117.5–202.0)	157.4 (120.6–199.9)	0.697
Operative time (minutes)	35 (25–45)	16 (13–20)	<0.001
Occupation operative room time (minutes)	73 (83–95)	44 (36–56)	<0.001
VAS POD 0	1 (0–3)	0 (0–1)	<0.001
VAS POD 1	2 (0–4)	2 (0–3)	0.089
VAS POD 2	1 (0–2)	0 (0–1)	0.002
Numbers of painkillers requested during POD 1	1 (1–2)	0 (0–1)	0.01
Length of post-operative hospital stay (days)	2 (2–2)	2 (2–2)	1
Post-operative 30-day complications (yes)	1 (0.4%)	1 (0.8%)	0.251
Transient recurrent laryngeal nerve palsy (yes)	1 (0.4%)	1 (0.8%)	0.251
Time of follow-up (months)	18.5 (15–30)	19.0 (14–27)	0.147

VAS—visual analogue scale. POD—post-operative hospital day.

4. Discussion

This retrospective study demonstrates that MIVAP under LA is related to several potential advantages in terms of operative time, occupation room time, and decreased post-operative pain.

pHPT is the predominant cause of hypercalcemia and should be considered if serum calcium levels increase [22–25]. The prevalence of pHPT is 0.86% in the USA and 0.73% in Europe [26,27]. Its incidence culminates in the seventh decade. It most frequently affects females (74%), though the incidence is similar in men and women before the age of 45 [28].

Symptomatic pHPT refers to the clinical presentation of the disease, independent from the localisation of the pathological gland detected through imaging. The symptoms are caused by hypercalcemia itself, typically with levels ranging from 13 to 16 pg/dL and are often accompanied by obvious skeletal and/or renal manifestations. This type of pHPT might be worsened in terms of clinical symptoms by a lack of vitamin D [4].

BNE has represented the gold standard in the treatment of pHPT for decades, with excellent results from experienced surgeons [29–31]. The development of pre-operative imaging techniques significantly impacted the surgical approach to parathyroidectomy, leading to a focused technique through a small neck incision. Minimally invasive operations for primary pHPT are linked to shorter operating times, rapid post-operative recovery, less post-operative pain, and lower incidence of complications [14,32,33]. Furthermore, while some authors have recently highlighted the significance of ioPTH monitoring as an "added value" for making surgical decisions, the majority agree that it plays a substantial, and maybe essential, supportive role in minimally invasive procedures. Barczynski et al. [34] showed that the standardised use of ioPTH considerably improved the success rates of minimally invasive open or video-assisted parathyroidectomy, compared to open image-guided unilateral neck exploration without ioPTH utilisation. Kim et al. [35] verified comparable outcomes when comparing minimally invasive parathyroidectomy procedures with and without ioPTH measurement. This evidence indicates that ioPTH monitoring is an essential tool to prevent surgical failure during MIVAP, even when pre-operative imaging for parathyroid localisation is consistent.

Concerning the type of anaesthesia, MIVAP-related low invasiveness and its technical similarity with the conventional open procedure also allow this approach feasibility under LA by means of cervical block [4].

LA for endocrine neck procedures has been introduced in our clinical practice since the early 2000s. In 2003, we described the feasibility of MIVAT under LA, reporting a case series of five patients without complications [16].

Previously published studies [13,36–38] showed several advantages favouring LA compared to GA in terms of shorter operative room occupation time, similar or shorter operative time, lower request for post-operative analgesics, and similar post-operative outcomes. Moreover, Melfa et al. [38] analysed the cost of parathyroidectomy in our healthcare system. The Italian Healthcare System's reimbursement is based on the Diagnosis Related Groups (DRGs) system, adopted by the specific regional governance. Delving deeper, the reimbursement in our region for parathyroidectomy is 2926 Euros (DRG 289).

In our analysis, we did not use a complete micro-costing bottom-up method because fixed costs for team, pre-operative, and post-operative diagnostic tests are the same. Likewise, other operative costs (consisting of extra resources specific for minimally invasive or video-assisted parathyroidectomy) were not considered due to the lack of significant differences between the groups regarding surgical technique. On the other hand, the type of anaesthetic and relative anesthesiologic technique are variable in terms of costs, and they vary together with the fluctuation of activity volume [3]. LA costs are less variable compared to those related to the GA. Cost analysis for this specific surgical procedure is challenging to realise due to several variables affecting the operative time. Concerning the operative room charges, a 2005 study of 100 U.S. hospitals found that OR charges averaged USD 62/min (range: USD 22 to USD 133/min), not including extra resources requested explicitly for the procedure. Depending on the hospital's pricing arrangement, some hospitals may reduce the cost of the operating room by 50% every minute after the first hour of surgery. Such calculation is made because the bulky supplies (custom pack opened, implants identified) and bulky support labour (room set-up, choosing of instruments) occur in the first part of the case. Furthermore, operative room costs can be variable or fixed, depending on the staff payment. Additionally, the expenses associated with the operating room can either fluctuate or remain constant based on the remuneration of the personnel. Indeed, suppose the payment for staff is based on an hourly rate. In that case, this can introduce an additional variable factor that complicates the precise assessment of the costs associated with the operating room. On the other hand, if the staff in the operating room receive a fixed wage regardless of how long the surgical operation takes, the expenditures remain constant. The time horizon, which refers to the duration in the future during which one assesses whether a cost is constant or variable, is also significant [3].

In our study, we compared 115 cases of LA MIVAP with 230 cases under GA using PSM. LA was realised by performing a modified superficial cervical block with the concurrent intravenous administration of remifentanil and midazolam [16]. As previously reported, the two groups are compared for demographic baseline characteristics. Both the operative time and the operative room occupation time were shorter in the LA group. Some may argue that such evidence is related to how ioPTH monitoring is performed differently in the two groups, as its use during GA parathyroidectomy determines the lengthening of operative room times, as reported in other published series [13]. During LA MIVAP, the patient occupies the operating room only for the time required for the surgical procedure, while ioPTH monitoring completion can be carried out in the recovery room. Whether the ioPTH curves indicate the need for further surgical exploration [3], this can also be realised using the contralateral cervical block, allowing either a unilateral or a bilateral neck exploration. Additionally, in our experience, LA group patients reported less pain during post-operative hospital stay and required fewer analgesic drugs in POD1. The difference in terms of pain between the two groups may be related to the absence of endotracheal intubation, a more comfortable position on the operating table, and/or the prolonged analgesic effect of the cervical block in the LA group. The absence of an endotracheal tube provides, theoretically, the additional benefit of a reduced risk of immediate bleeding at the end of the surgical procedure by severe coughing at the time of extubating [16]. As also reported in other series [13], we observed less frequent episodes of nausea and vomiting when LA was used. We registered only two cases of post-operative complications: a case of transient nerve palsy per group, similar to Joliat et al. [39] results, reporting 3% post-operative recurrent laryngeal nerve palsy. It is important to note that intraoperative neuromonitoring cannot be performed during LA. Therefore, acquiring proficiency in the surgical method and successfully completing the necessary learning process before carrying out LA surgeries is advisable.

Our analysis confirms that LA MIVAP is feasible and safe. Moreover, the shorter operative room time in the LA group suggests that such a procedure is economically convenient and suitable for our operative room labour, with the staff paid by salary. Furthermore, the operative room time is not affected by ioPTH monitoring so that the subsequent surgical procedures can be scheduled more precisely. Indeed, the median operative room time of the GA group is twice as great compared to the LA group.

This study has several limitations. The main limitation is its retrospective nature (using a *per protocol analysis*) in patients who underwent focus (single) MIVAP for pHPT sustained by the (single) parathyroid adenoma. Moreover, the study time is bound to extend several decades to achieve a sufficient sample size; this clearly affects clinical experience in the post-operative management of patients. Similarly, the long inclusion period of this study can be considered a confounding factor for surgical expertise, which influences operating times and complications. However, it should be emphasised that most of the surgical procedures included in this study were performed by the same experienced endocrine surgeon (M.R.) who had already completed the learning curve prior to the start of recruitment. Moreover, the choice of anaesthesia was not randomised. On the other hand, all procedures have been performed in high-volume endocrine referral centres, so this would theoretically ensure homogeneity in surgical indications, pre-operative patient study, and treatment. However, it is worth noting that this study was conducted in the centre where MIVAT was initially developed and described, beginning with the initial description of MIVAT by Prof. Miccoli and coworkers [9]. This highlights the extensive expertise in video-assisted neck endocrine procedures. In addition, the centre's proficiency in minimally invasive surgeries is demonstrated by its early adoption and enhancement of procedures such as robotic trans-axillary thyroidectomy, which was introduced approximately ten years ago, and the transoral endoscopic thyroidectomy vestibular approach (TOETVA), which will be implemented in 2024. Also, LA is a minimally invasive technique applied to our clinical practice since the early 2000s. It allows for performing neck endocrine procedures, such as thyroidectomies and parathyroidectomies, in patients who may not be suitable candidates for general anaesthesia. So, our Centre has gained extensive competence in tailoring the surgical method that provides the most benefit to patients. To clarify, it is essential to note that this does not eliminate the need to conduct studies (both retrospective and prospective) using an intention-to-treat analysis design. These studies are necessary to accurately evaluate the conversion rates between the two anesthesiological approaches and determine the instances where a second surgical exploration is required when the Rome criteria are not met.

5. Conclusions

The success of MIVAP has been established by several studies, showing equivalent cure and complication rates to those achieved by conventional BNE. The two anaesthesiologic techniques applied to focus parathyroidectomy evaluated in this study were safe and effective, with comparable cure rates. The use of LA for MIVAP was found to result in quicker operating time and decreased post-operative pain compared to doing the same procedure under GA. Furthermore, LA MIVAP is economically convenient for our Healthcare System, as operative room occupation time only does not rely on ioPTH monitoring and anesthesiology procedure, thus allowing a more precise planning of operating sessions.

Further randomised studies, with cost analysis, are still necessary to evaluate whether one technique should be preferred.

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Institutional Review Board Statement: All data for this retrospective study have been institutionally collected in a prospectively designed database for endocrine neoplasm after approval by the Ethical Committee of our centre (Eurocrine® registry, ID 1416) for future retrospective studies. A formal evaluation by the Ethical Committee of this specific retrospective study was not requested, as it was unnecessary. This study was conducted according to the guidelines of the Declaration of Helsinki.

Informed Consent Statement: Informed consent for future retrospective studies was administrated to all patients at index operation.

Data Availability Statement: The data are stored in an electronic database and available from the corresponding author.

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