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ORIGINAL ARTICLE

Less-than-subtotal parathyroidectomy as treatment for primary hyperparathyroidism in multiple endocrine neoplasia-type 1: a good option?

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Abstract

Introduction: Multiple endocrine neoplasia type 1 (MEN1) is a genetic syndrome manifested initially as primary hyperparathyroidism (HPT/MEN 1). The treatment is classically surgical with total parathyroidectomy with autograft or subtotal parathyroidectomy. In order to maintain normal postoperative function, less than subtotal parathyroidectomy (LTSPTx) has been suggested as an alternative technique. **Objective:** Analyse critically LTSPTx as a treatment option for patients with HPT/MEN 1. **Methods**: A retrospective cohort study of patients submitted to LTSPTx from january 2011 to december 2018. Data from demographics, laboratory tests, 6 months postoperative clinical outcomes, intraoperative PTH values and localization studies were analized. **Results:** LTSPTx was performed non-intentionally in 13 patients and intentionally in 13 other cases; 17 females and 9 males. The mean age was 44 years, but in patients with identified mutation it was 37 years. Seventeen patients (65.4%) had normal parathyroid function, 5 (19.2%) had hypoparathyroidism, in all of them LTSPTx was performed non intentionally. Four patients (15.4%) had persistence, all submitted intentionally to LTSPTx. The mean intraoperative PTH drop was 85.5% (±10.4%), without difference intergroup. A patient with persistence had PTH intraoperative drop > 80%, which also occurred in another patient with postoperative hypoparathyroidism. No persistence was found in patients with concordant image exams, what happened in three cases with non-concordant studies. **Conclusion:** LTSPTx may be intentionally performed as treatment for HPT/MEN 1, however social aspects, technical expertise, image exams and patient expectations must be taken into account.

Keywords: parathyroidectomy; type 1 multiple endocrine neoplasia; hypoparathyroidism.

Introduction

Multiple endocrine neoplasia-type 1 (MEN1) is a genetic syndrome transmitted by a dominant autosomal inheritance pattern which determines high predisposition to the development of endocrine and non-endocrine tumors.

It is caused by mutations in the MEN1 tumor suppressor gene *locus* on chromosome 11q13, which codifies a protein named MENIN, of mainly nuclear expression[1-3]. It has full penetrance, and in 80-100% of the cases, the first clinical manifestation occurs through primary hyperparathyroidism (PHT/MEN1)[4-6].

Differently from sporadic primary hyperparathyroidism, in which the disease occurs through uniglandular involvement (adenoma in 80% of the cases)[6,7], in PHT/MEN1 hyperplasia occurs in one or more parathyroid glands with asymmetric involvement[6,8]. Thus, most of authors advocate that surgery for PHT/MEN1 treatment should be performed through bilateral cervical approach with identification of all parathyroids[9].

The most recognized surgical options are the total parathyroidectomy with autograft (TxPT+AG) and the subtotal parathyroidectomy (SxPT)[9,10]. TxPT+AG consists of a bilateral cervical approach with excision of all parathyroids, followed by heterotopic autograft of gland fragments, which are macroscopically presented as less affected[11]. In MEN1 cases, it takes this autograft nine months on average to reach a parathormone (PTH) production sufficiently efficient to maintain the patient in euparathyroidism, but this period may be longer[12,13]. Thus, until this effectiveness is achieved, the patient is dependent on calcium and vitamin D reposition; in addition, the autograft may not produce enough PTH and hypoparathyroidism can occur.

SxPT also has a bilateral cervical approach, but with the intention of leaving a stump of one of the parathyroids in the cervical bed with an aspect more similar to that of a normal gland, and excision of at least three parathyroids is quite frequent. In this case, local anatomic factors and the stump vascularization characteristics may influence its postoperative feasibility and efficiency.

SxPT is a preferred option in most surgical services because it presents a smaller potential risk of permanent hypoparathyroidism, considering that this complication can greatly impact patient quality of life[10,14]. Thus, considering several surgical series, hypoparathyroidism prevalence in SxPT is 0-35%, whereas in TxPT+AG it varies from 0 to 50% (15). However, PHT/MEN1 persistence and recurrence indexes are quite similar in both techniques, varying between 17 and 19%[15-17].

In the search for lower indexes of permanent PHT/MEN1, the concept of minimally invasive parathyroidectomy, that is, "less-than-subtotal" parathyroidectomy (LTSPTx), was developed. In this technique, studies of concordant localization, such as cervical ultrasound (US), ^{99m}TC-Sestamibi scintigraphy (MIBI scan) and/or computed tomography (CT), assist the surgeon with the performance of a lateralized surgery. The proposal is to excise two parathyroids on the approached side, considering that one or two are dominant and that the contralateral glands are little or not altered. With this more restrictive manipulation, occurrence of hypoparathyroidism can be avoided[10]; however, because this is a known multiglandular disease, there is higher risk of PHT/MEN1 persistency and recurrence[4].

In LTSPTx, or unilateral clearance[7], the parathyroids are approached on only one side of the neck, as well as intentional excision of the ipsilateral thymus (LTSPTx-I). Thus, only patients who present positive localization studies on a

single side, either for one or two ipsilateral hyperplasic glands, are eligible to be submitted to this technique.

This type of surgery has presented results similar to those of SxPT, but with no persistent PHT/MEN1; however, some studies have shown that surgeries using restrictive approaches present higher recurrence rates[4,7]. The great advantage of unilateral clearance is that, despite the risk of reoperation, it enables PHT/MEN1 recurrence correction through reoperation on a cervical bed that has not been previously manipulated, as in a first cervical approach.

It is worth highlighting that some LTSPTx are performed unintentionally (LTSPTx-NI), that is, when the initially planned surgery was TxPT+AG or SxPT, but there is no success in the identification of at least four parathyroid glands. It is a major frustration for the surgeon, because there is preoccupation with the possibility of being a non-resolving approach with probable persistence. However, the opposite was also observed: almost one-third of these patients remained with hypoparathyroidism and only approximately 15% of them presented persistence or recurrence[4].

In this context, surgeries personalized for each patient have been increasingly sought for the treatment of PHT/MEN1[18] aiming at prolonged euparathyroidism and better patient quality of life. LTSPTx-I seems possible in approximately 22% of the cases (rate of patients with positive and concordant examinations in a single side of the neck) (4); however, this surgical method has been proposed only recently[10] and is not yet recognized, which makes its study relevant.

This study aimed to critically analyze less-than-subtotal parathyroidectomy (LTSPTx) for the surgical treatment of patients with primary hyperparathyroidism (PHT/MEN1).

Methods

This study is part of a research project called "Impact of histologic, molecular and genetic changes on the surgical treatment and clinical evolution of patients with primary hyperparathyroidism associated with multiple endocrine neoplasia-type 1 (PHT/MEN1)" approved by the Ethics Research Committee of the aforementioned Institution (CAPPesq) under no. CAAE 49697715.6.0000.0068.

This is a retrospective cohort study conducted with patients undergoing surgical treatment for primary hyperparathyroidism (PHT/MEN1) at the Head and Neck (H&N) Surgery Service in partnership with the Endocrinology and Pathological Anatomy Service of the *Hospital das Clínicas*, College of Medicine, University of Sao Paulo (HC-FMUSP) between January 2011 to December 2018.

MEN1 diagnosis was performed through the clinical manifestation of at least two of the three diseases described in this syndrome (hyperparathyroidism, hypophyseal adenoma, intestinal neuroendocrine tumor) and/or through genetic screening, in which MEN1 gene mutation was identified.

Indication for surgical treatment was absolute in symptomatic patients. In asymptomatic patients, indication for surgery was based on the Consensus Guidelines for Asymptomatic Sporadic Primary PHT[4], except for the age criteria, once most of the patients are aged <50 years when disease is detected, and the

benefit of surgery for these specific cases is still not clear. Therefore, patients with the following lesions in the target organ or changes in laboratory chemical profile were submitted to surgical treatment: nephrolithiasis, nephrocalcinosis, osteoporosis, total calcium 1mg/dL above the reference value, renal function change with creatinine clearance <60 mL/min, or hypercalciuria with 24-hour urine calcium >400 mg/volume.

Inclusion criteria. Patients with indication for total parathyroidectomy with autograft (TxPT+AG) and subtotal parathyroidectomy (SxPT) and whose anatomic-pathologic study revealed excision of three or fewer parathyroid glands, respectively, were analyzed, being classified as unintentional less-than-subtotal parathyroidectomy (LTSPTx-NI).

Patients submitted to initial unilateral clearance, classified as intentional less-than-subtotal parathyroidectomy (LTSPTx-I), were also included in the survey.

Exclusion criteria. Patients successfully submitted to TxPT+AG and/or SxPT or with postoperative follow-up <6 months were excluded from the study.

Analyzed variables

A) Demographic profile: patients' age and gender; presence or not of mutation identified by genetic screening;

B) Laboratory chemical profile [normality reference]: total serum calcium (CaT) [8.6-10.2mg/dL], serum ionized calcium (iCa) [4.6-5.2mg/dL], serum phosphorus (P) [2.7-4.5mg/dL], and serum parathormone (PTH) at pre-surgery and six months post-surgery [15-65pg/mL].

C) Patient clinical outcome six months after surgery:

1) Hyperparathyroidism: low systemic PTH, normal calcium levels, or low calcium levels maintained with the use of calcium medication and/or calcitriol;

2) Euparathyroidism: normal systemic PTH, normal calcium levels without use of medication;

3) Hyperparathyroidism: high calcium levels with high or inappropriately high systemic PTH. The patients in this condition up to 6 months postoperatively were considered with disease persistence.

Patients that presented hungry bone disease, that is, normal or high systemic PTH, with calcium and/or calcitriol replacement and normal or low calcium levels, were included in the group of patients with euparathyroidism, considering that the surgical treatment was effective for them.

D) Intraoperative parathyroid hormone (IO-PTH) curve:

According to the routine established by the Service, PTH samples are collected at five different moments:

- PTH peripheral baseline: collected at anesthesia induction from an upper or lower limb peripheral vein;

- PTH central baseline: collected right after cervical dissection from an internal jugular vein;
- PTH pre-excision: collected from the same internal jugular vein in which the central basal PTH was collected, soon after identification and dissection of the parathyroids to be excised, or from the ones that could be identified;
- PTH 10 min: collected from the same internal jugular vein 10 min after excision of the target parathyroids, or from the ones that could be identified;
- PTH 15 min: collected from the same internal jugular vein 15 min after excision of the target parathyroids, or from the ones that could be identified.
- PTH decay rates were analyzed 10 and 15 min after excision of the glands in relation to the pre-excision highest value (PTH peripheral and central baseline or pre-excision).

E) Complementary localization studies - cervical ultrasound (US) and ^{99m}TC-Sestamibi scintigraphy (MIBI scan and US): concordance or not between the suggestive images of localization of the parathyroids were analyzed from these two preoperative examinations.

Statistical analysis. Data were statistically analyzed using the GraphPad Prism 5.0 software. The continuous numerical variables were tested for normality by the Kolmogorov-Smimov test. The values were expressed as mean and standard deviation (±SD) when distribution was normal and as median and interquartile range when this situation did not occur. The qualitative variables were expressed as number and frequency. The quantitative variables were compared using the unpaired "Student's *t*-test in cases of normal distribution and with application of the Mann-Whitney test for non-parametric distributions. The Chi-squared test was used to compare the qualitative variables between groups, whereas the Fisher's exact test was applied when the comparison occurred between the two groups. A significance level of 5% (p<0.05) was adopted for all statistical analyses.

Results

Between January 2011 and December 2018, 113 patients were submitted to surgery to resolve primary hyperparathyroidism (PHT/MEN1) at the aforementioned Institution. Twenty-six patients undergoing less-than-subtotal parathyroidectomy (LTSPTx) were included in the study: 13 unintentional (LTSPTX-NI) (50%) and 13 intentional (LTSPTX-I) (50%) cases.

Age range of the patients was 14-78 years (mean age = 44 ±17 years). Regarding gender, there were 17 females (65.5%) and nine males (34.5%). Preoperative biochemical analysis of the 26 study patients showed Cat = 10.8 mg/dL (±0.8), iCa = 5.9 mg/dL (±0.7), P = 2.8 mg/dL (±0.5), and PTH = 133 pg/dL (106–192).

Genetic mutation screening for multiple endocrine neoplasia-type 1 (MEN1) was performed in 25 of the 26 patients in the sample. Of the patients who underwent this screening, 17 harbored mutation: nine males and eight females aged 37 (±13) years. All patients (8) with negative mutation screening were females aged 58 (±16) years at the time of surgery. In addition to the expressive

difference in frequency regarding gender, the mean age of patients harboring genetic mutation was lower compared with that of patients with negative mutation results, with statistical significance (p=0.002).

Mean age of the patients submitted to LTSPTX-I was 42 (±18) years, whereas mean age of those undergoing LTSPTX-NI was a little higher, 46 (±17) years, but not statistically significant. Frequency by gender was not different between the groups (Table 1).

Table 1. Pre- and postoperative demographic and laboratory profiles and clinical outcome of the patients.

	UNINTENTIONAL (n=13)	INTENTIONAL (n=13)	*p*
AGE in years (±SD)	42 (±18)	46 (±17)	0.58
F: M	8: 5	9: 4	1
PREOPERATIVE BIOCHEMICAL PROFILE			
Ca (mg/dL)	10.8(±0.8)	10.8 (±0.8)	0.80
iCa (mg/dL)	6.0 (±0.6)	5.8 (5.5-6.0)	0.42
P (mg/dL)	2.8 (±0.6)	2.8 (±0.5)	0.90
PTH (pg/mL)	155 (116-220)	123 (72-136)	0.07
POSTOPERATIVE BIOCHEMICAL PROFILE (6 months)			
CaT (mg/dL)	9.4 (±1.1)	9.7 (±0.7)	0.31
iCa (mg/dL)	4.8 (±0.6)	5.2 (±0.4)	0.06
P (mg/dL)	3.9 (3.2-4.1)	3.3 (±0.5)	0.02
PTH (pg/mL)	23.7 (±16.6)	53.2 (±16.8)	0.0002
CLINICAL OUTCOME			
EUPARATHYROIDISM	8 (61.5%)	9 (69.2%)	*
HYPOPARATHYROIDISM	5 (38.5%)	0 (0.0%)	
PERSISTENT PHT/MEN1	0 (0.0%)	4 (30.8%)	

Caption: M= male gender; F= female gender; CaT= total serum calcium, iCa= serum ionized calcium; P= serum phosphorus; PTH= serum parathormone; PHT/MEN1= primary hyperparathyroidism; *vide text.

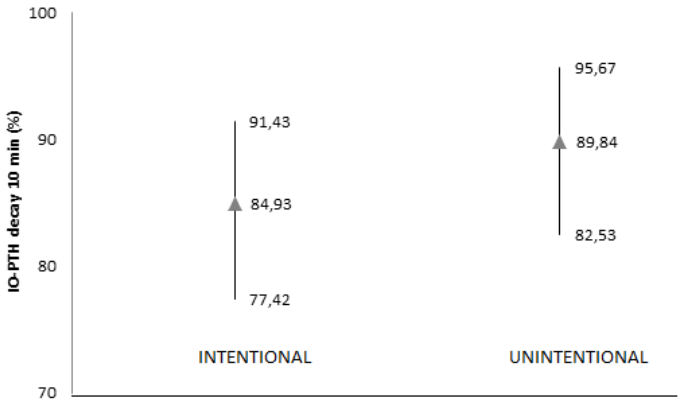
Table 1 shows the detailed characteristics of the patients submitted to LTSPTx-I and LTSPTx-NI with respect to their pre- and postoperative biochemical profiles, as well as the clinical outcomes six months postoperatively. It can be observed that 17 patients developed euparathyroidism (65.4%); in the LTSPTx-NI group, five (19.2%) patients presented hypoparathyroidism; in the LTSPTx-I group, four (15.4%) patients showed persistent PHT/MEN1.

The mean PTH decay 10 min, compared with the highest value prior to excision of the parathyroid glands, was 85.5 (±10.4%). No statistically significant difference was observed for PTH decay 10 or 15 min in the comparison between the two groups (LTSPTx-I and LTSPTx-NI) (Table 2) (Graph 1).

Table 2. Intraoperative parathormone (IO-PTH) decay in percentage.

	UNINTENTIONAL (n=13)	INTENTIONAL (n=13)	*p*
PTH 10 MIN	38.2 (±22.6)	51 (30-81)	0.19
PTH 15 MIN	32.6 (±16.6)	45 (30-69)	0.07
PTH DECAY 10 MIN	87.2 (±10.6)%	83.7 (±10.3)%	0.40
PTH DECAY 15 MIN	89.2 (±8.2)%	87.7 (71.1-91.4)%	0.21

Caption: PTH= serum parathormone; MIN= minutes.



Graph 1. Median and interquartile range for intraoperative parathormone (IO-PTH) decay 10 min after intentional or unintentional less-than-subtotal parathyroidectomy (LTSPTx).

In the group with persistent PHT/MEN1, only one patient presented intraoperative parathormone (IO-PTH) decay 10 min <80%; however, this fact also occurred with another patient that developed postoperative hypoparathyroidism.

Analysis of the absolute IO-PTH 10 and 15 min values after excision of the parathyroids showed that only six patients presented PTH 10 and 15 min above the reference value (65 pg/mL) adopted by the Institution, whereas 20 patients showed values within normality. Comparison between the evolution of these patients, PTH 10 min and PTH 15 min, postoperatively showed that 16.7% (1/6) and 20% (4/20), respectively, developed hypoparathyroidism, whereas 33% (2/6) and 10% (2/20), respectively, presented disease persistence, without statistically significant differences (p=0.22).

Localization studies were not available for six patients. Of the 20 patients with available localization images, seven (35%) presented concordant results for US and MIBI scan, two with bilateral images and five with unilateral images; eleven (55%) patients showed discordant images; two (10%) patients did not

have their parathyroids identified through the image localization studies performed.

In the cases with concordant images, either unilateral or bilateral, none of the patients developed postoperative PTH/MEN1 persistence, whereas three patients with discordant studies presented persistence.

Discussion

This study showed coincidental sample between the intentional (LTSPTxI) and unintentional (LTSPTxNI) groups analyzed. Most of the study sample was composed of females and the mean age of the analyzed patients was 40 years, corroborating the data reported in other studies in the literature[4,6,7]. The reason for the larger number of female patients submitted to surgery is not clear, considering that disease penetrance is not associated with gender. One hypothesis is that female patients tend to take better care of their health perhaps looking forward to a future pregnancy, considering that many of them are in fertile age. However, other factors can be related to this fact, such as a greater tendency for development of clinical manifestations in women: there is a series of other non-endocrine tumors associated with this syndrome (e.g., breast cancer or collagenomas) that can lead women to seek medical assistance.

In the present study, it was observed that when genetic MEN1 mutation is identified the age range of surgical treatment indication is smaller, suggesting that in these cases disease aggressiveness may be higher[4]. This study did not address the types of mutation; however, Kluijfhout et al.[7] associated mutation in the exons 2, 9, 10 with greater disease aggressiveness. In contrast, it is likely that progress in molecular biology and genetic research in medicine allow PHT/MEN1 patients to be treated at an earlier stage of the disease. Thus, it will be possible to offer several surgical options according to these mutations, as well as to weight the risks and benefits at the choice of more or less radical surgical techniques.

Despite the benefits of an early diagnosis and treatment of PHT/MEN1 from genetic screening, persistent hypoparathyroidism is a significant preoccupation. It has a great impact on the quality of life of patients, who are increasingly younger when undergoing surgical treatment. For this reason, indication of LTSPTx-I has received increasing attention. This study demonstrated that patients submitted to LTSPTx-NI had 6-month postoperative PTH values statistically lower than those of patients undergoing LTSPTx-I, suggesting that the exhaustive search for a single and definitive approach of the neck can be more harmful than planned reoperations.

Montenegro et al.[4], Kluijfhout et al.[7] and Fyrsten et al.[6] demonstrated that unilateral clearance (LTSPTx-I) in well-selected cases prevents hypoparathyroidism, theoretically enabling long-term adequate bone remodeling and growth; however, follow-up in these studies was short. In contrast, LTSPTx-NI may present hypothyroidism rates similar to those in TxPT+AG and SxPT. Thus, there is an alert for surgeons, who should always be aware of the risks and benefits of keeping a persistent search for the four

parathyroid glands. Only two unintentional surgeries were performed after 2014, because the Institution began to indicate unilateral clearance initially.

In contrast, in the present study, four patients (15.4%) submitted to LTSPTx-I presented PTH/MEN1 persistence. Fyrsten et al. (6) also associated less invasive surgeries with higher recurrence rates. Despite the high risk of PHT/MEN1 recurrence, because clearance is a unilateral approach, it keeps the cervical bed intact for future reoperations, theoretically not presenting difficulties and morbidities as in SxPT[7]. Perhaps the risk of reoperation, with low morbidity, is justified by the low risk of hypoparathyroidism, especially in asymptomatic patients, whose only surgical indication is change in bone mineral density, with no clinical manifestation; or even in those who will need short-term total pancreatectomy, which will incur in difficulties in calcium absorption and management.

In the present study, the mean highest IO-PTH decay value, either after 10 or 15 minutes, in relation to the highest previous value, either at pre-excision or baseline, was 87.4%. However, even the patients with disease persistence presented high IO-PTH decay values, most of them >80%. Only one patient showed a PTH decay value <80%, but >70%. These data suggest that a high IO-PTH value does not guarantee non-persistence of the disease. The IO-PTH value in LTSPTx is useful to assist with cases when there is doubt whether the dominant and most affected gland was dully excised. A study conducted by Montenegro et al.[4] suggested higher PTH decay cut-off points for MEN1 patients submitted to LTSPTx, evidencing that even 90% PTH decay can cause disease persistence, a value more demanding than the 71% suggested by Kluijfhout et al.[7].

Intraoperative PTH decay percentage for PHT/MEN1 should be analyzed with caution. The Miami criteria used at sporadic uniglandular PTH, which predicts a decrease >50% after 10 min, is many times extrapolated for use in MEN1 patients[18], which is not adequate for a multiglandular disease. Similarly, using PTH 10 min decay values >80%, as in patients with multiglandular diseases associated with chronic renal disease submitted to TxPT+AG[19], should not be extrapolated for SxPT and LTSPTx, considering that the residual cervical tissue continues to produce PTH (at uncertain proportion) during IO-PTH measurement 10 min after excision of affected glands. Therefore, further studies to define a criterion for PTH decay are needed, especially with MEN1 patients, considering that even significant IO-PTH decays, many times >80%, are still not sufficient to predict PTH persistence.

In addition to the decay values, the absolute PTH 10 and 15 min values were also not able to suggest the clinical evolution for postoperative PTH/MEN1 persistence. To date, IO-PTH has not been considered a good predictor of postoperative evolution; however, its use is justified because, by indicating little significant decays (<50%), it determines the need to carry on with resection.

Cervical US and MIBI scan are available methods for localization of parathyroid hyperplasia[7]. These two image techniques for disease screening are routinely used at the Institution, either for primary or secondary PTH/MEN1 cases. In this study sample, all patients submitted to LTSPTx-I that presented disease persistence had at least one examination suggestive of bilateral disease.

In fact, interpretation of the surgeons involved differed from the technical report, and they interpreted the disease as unilateral. This misconception can be associated with the fact that the images available in the electronic health record have poorer resolution than those available to the examining physicians. Anyway, this observation reinforces what is suggested in the literature: patients with any localization studies suggestive of bilateral disease should not be eligible to LTSPTx-I[4,7] even if the IO-PTH is >80%. This fact reinforces the importance of image examinations for the adequate preoperative selection of patient candidates to this type of surgery. However, Kluijfhout et al. suggest that unilateral clearance (LTSPTx-I) be performed only on patients that present concordant and unilateral examinations, US and MIBI scan. Four-dimensional computed tomography (4D CT) has been gaining wider acceptance, and may be a useful resource in the selection of patients for LTSPTx-I; however, exposition to radiation should be considered.

LTSPTx-I (unilateral clearance) is a relatively recent technical option for which reference services are still gaining experience. It is worth highlighting that until 2014 TxPT+AG was the only surgical technique used at the Institution. As of that year, SxPT started to be used as an alternative and LTSPTx-I began to be indicated only as of 2017. Thus, only two unintentional surgery types have been performed as of 2014.

It is essential to consider the peculiarities and wishes of each individual in the election of patient candidates for this restrictive approach. During the consenting process for the procedure, the risks of PTH/MEN1 persistence and the null indexes of hypoparathyroidism should be widely discussed with the patients. In addition, the social conditions should be evaluated, as well as the ease of access to the health service, because many patients in Brazil still face difficulties in the acquisition of calcium carbonate. Despite the fact that access to medication be regulated by the National Health System (SUS), whose financing is ensured by the Federal, State and Municipal governments (decree GM/MS no. 1.555 of July 30, 2013), its unavailability is not rare, even in tertiary services in major cities. Furthermore, lack of knowledge about this rare disease and possible surgical treatments many times result in failure in the diagnosis of hypocalcemia and its adequate treatment, which could lead to death.

A limitation to this study is its apparent small sample size; however, the fact that PTH/MEN1 is a rare disease implies a limited sample for any analysis. Nonetheless, when compared with other studies available in the literature, the 26-patient sample of this study is significant[4,7].

Another aspect subject to criticism is the fact of being a retrospective study. It is believed that, in face of the presented results, randomized studies would be unethical, considering that a specific type of surgery (TxPT+AG, SxPT, or LTSPTx-I) is more adequate for each patient, thus it is not possible to use a technique defined by a randomized process.

Conclusion

Less-than-subtotal parathyroidectomy (LTSPTx) can be intentionally indicated for the treatment of primary hyperparathyroidism (PHT/MEN1), but the use of this new technique that should be carefully analyzed for each patient

considering social aspects, technical expertise, image localization studies, and patient expectations. The intraoperative parathyroid hormone (IO-PTH) was not able to predict success in this type of surgery.

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