Bilateral Thoracoscopic Sympathectomy for Primary Palmar Hyperhidrosis, Which Level: T3 or T4?

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ABSTRACT

Background*: Primary palmar hyperhidrosis (PPH) is an extremely disabling condition that affects the patients' quality of life. Thoracoscopic sympathectomy (TS) is a highly safe & effective modality of treatment and compensatory sweating (CS) is the most common unavoidable side effect. There is still a debate regarding the optimal number & level of sympathetic ganglia to be targeted.* ***Aim****: This study aimed to compare T3 & T4 ganglionectomy regarding efficacy, complications, side effects & patients' satisfaction.* ***Patients & Methods****: Forty patients with PPH were divided into 2 groups 20 patients each: group A underwent bilateral TS at T3 level & group B at T4 level. Efficacy, complications, side effects & patients' satisfaction were compared among both groups.* ***Results****: Thoracoscopy related complications were mild & self limiting. Both levels were equally effective (100%) with no recurrence after one year. CS occurred in 95% in T3 group & in 60% in T4 group (significant) and severe CS occurred in 20% in T3 & in 5% in T4 (insignificant). Hands over-dryness occurred in 10% in T3 & in 0% in T4 (insignificant). Gustatory sweating occurred in 15% in T3 & in 0% in T4 (insignificant). Marked satisfaction was 20% in T3 & in 60% in T4 (significant). Overall satisfaction & dissatisfaction were 75 % & 10% in T3 and 90% & 0% in T4 respectively (both insignificant).* ***Conclusion:*** *PPH can be effectively treated by either T3 or T4 TS, with high rates of patient satisfaction. T4 TS appears to be superior to T3 as it is associated with less severe CS & higher patients' satisfaction rates and should be the denervation level of choice. However, this finding should be validated in high-quality, large-scale randomized controlled trials.*

Key words: *Primary hyperhidrosis, Palmar, Thoracoscopic Sympathectomy, Compensatory Sweating.*

INTRODUCTION

Hyperhidrosis is a condition of sweating greater than physiologically required for normal body thermoregulation. It may develop secondary to a variety of medical disorders or it may be primary. Idiopathic or Primary hyperhidrosis (PH) affects palms, axillae, soles or face or in combination [(1,2)]. Although its accurate pathophysiology is still unknown, it is believed to be caused by overactivity of the sympathetic nervous system at the upper thoracic ganglia level to the normal eccrine sweat glands responsible for the excessive sweating [(3)]. It is generally believed to result from an exaggerated central response to normal emotional stress or environmental stimuli that usually begins in childhood or adolescence[(1,4,5)].

Primary hyperhidrosis is thought to affect 1-3% of the population, with predominance in countries near the Equator. PH affects both sexes equally & affects predominantly adolescents or young adults with higher incidence among the first degree relatives of PH patients[(6)]. Although PH is not a life-threatening condition, it can have a deeply detrimental impact on a patient's quality of life (QoL). PH, especially palmar type, can cause severe impairment of psychological & social interactions, daily, educational and occupational activities [(7,8)].

A careful clinical evaluation based mainly on patient's history, complemented by physical examination, are the most valuable tools and are usually enough to establish the diagnosis of PH. In most cases, laboratory & radiological tests are not necessary, but may be required mainly to exclude a secondary cause[(1,9)]. PH is a condition diagnosed by a focal, visible & excessive sweating of more than 6 months accompanied by 2 of the following characteristics: bilateral & symmetric symptoms, onset before age 25 years, impairment of daily activities, at least 1 episode per week, sweating ceases during sleep &/or a family history of PH [(1,2)].

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A wide variety of non surgical treatments can be tried for PH as oral anticholinergic drugs, topical aluminum or anticholinergics based antiperspirants, Iontophoresis and Botulinum toxin injections. These treatments are indeed less invasive than surgery, but all of them have a palliative role, temporary benefits & high cost & they are not without side effects [8,10,11]. Once therapy is interrupted, the symptoms will relapse in virtually all patients. From a practical point of view, these methods can be used effectively in mild cases and the majority of patients with severe cases will eventually end up seeking for a surgical solution [9].

The main surgical management of PH entails bilateral interruption of the upper thoracic sympathatic chains anatomically located anterior to the inner aspects of upper ribs [1,12]. The availability & development of the thoracoscope as a minimally invasive tool and the evolution of video assisted thoracoscopy, have contributed to the establishment of thoracoscopic sympathectomy (TS) as the current standard definitive treatment of severe cases of PH, with very high safety & efficacy, a high rate of patient satisfaction and minimal morbidity [4]. Different levels of sympathetic ganglia have been approached with different types of PH; palmar, axillary or craniofacial and different techniques of interruption as division, ganglia excision or clipping have been practiced[6,8]. Previously primary palmar hyperhidrosis (PPH) was managed by extended level T2-4 sympathectomy & later this was modified to two levels & single level surgery [8,13]. The best results after TS are achieved with PPH patients, in which symptoms disappearance & QoL improvement are almost 100% [6,9].

The complications related to thoracoscopy as hemothorax, pneumothorax, wall infection, pleural effusion, chylothorax, pleural adhesions, subcutaneous emphysema, intercostal neuralgia & pulmonary edema, have been rarely described[4,6,14]. Failure with the need for a second sympathectomy have been reported, although all failure cases were usually attributed to some anatomic variants (6,8,15). Horner's syndrome was previously encountered frequently with older techniques; T2 dissection but rare nowadays[6,16]. Rarely, sympathectomy may cause changes in cardiopulmonary function mainly bradycardia & bronchial hyper-reactivity [17].

However, the most significant complications of TS are compensatory sweating (CS) & dry hands[4,8,18]. CS - which can occur in different body regions as abdomen, chest, back & thighs - is the most common & undesirable long term side effect of TS [6,19]. It is the leading cause of patient dissatisfaction and is considered to be the "quality marker" of TS [13,19,20]. CS occurs at a rate of 3% to 98% depending on the level, technique & how it has been assessed [6,13,21]. Gustatory sweating is an uncommon side effect that can occur in up to 1/3 of patients and it is characterized by increased facial sweating with ingestion of sour/spicy foods and drinks [9,22].

Various methods have been tried to decrease the incidence of complications after TS [23,24]. However, controversy remains regarding the appropriate level and number of ganglia to be removed for the best outcome [21,25]. It appears that CS is more severe with the removal of more ganglions [19,23]. It is generally believed that as the level of sympathetic chain interruption is lowered, the rate of CS decreases, but the risk of postoperative recurrence increases [16,19,20]. Several authors have performed TS at a single level and achieved a better curative effect (similar symptoms resolution & lower CS rates) than that with multiple levels[23,24,26]. With more understanding of TS, single level surgeries for PPH, especially T3 or T4 levels, became increasingly common[6,24,27]. T4 level TS has been recommended for the treatment of PPH under the Lin-Telaranta classification (28). T4 interruption alone may be appropriate to limit the likelihood of CS, although it may result in moister hands [6,13].

There is no widespread consensus in the literature regarding the relationship between ganglion level & number of ganglions interrupted & the prevalence of CS, as results vary among studies, possibly due to a lack of large-scale clinical research in this field [21,24,25,29]. In an attempt to resolve this issue & optimize the surgical procedure required for PPH, we performed this study comparing T3 & T4 TS to compare efficacy, complications, side effects & patients' satisfaction.

PATIENTS AND METHODS

This prospective randomized study was conducted during the period from May 2015 to February 2019 on 40 patients who underwent

Bilateral TS at the General Surgery Unit at Ain Shams university hospitals for PPH. The study included PPH patients (alone or with axillary) with failed conservative management. The study excluded recurrent hyperhidrosis, extremes of age (<18 & >60), morbid obesity (BMI >40), patients unfit for thoracoscopy (previous major thoracic surgery, severe lung disease) & patients with bradycardia (<55 bpm) or arrhythmias. Patients were followed-up for clinical outcome for at least one year.

The 40 patients were divided into 2 equal groups (20 each) by simple random sampling method from patients attending the clinic: group A patients underwent bilateral TS at T3 ganglia level, while group B patients underwent bilateral TS at T4 ganglia level. A written informed consent was obtained from the patients after explaining the procedure, possible complications and their enrollment in a clinical study. This study was approved by the Ethical Committee of the Faculty of Medicine, Ain Shams University.

All patients were subjected to clinical assessment that included history [Age, Gender, duration of symptoms before surgery, severity of the condition using Hyperhidrosis Disease Severity Score (HDSS: table 1) & other associated medical conditions] and previous trials of treatment. The patients were evaluated by routine preoperative investigations (Complete blood count, bleeding profile, liver enzymes & renal function tests) including chest X-ray, ECG & pulmonary function tests (as required) to avoid perioperative morbidity in patients with major lung pathology.

Table 1: Hyperhidrosis Disease Severity Score (HDSS): Data taken from [30].

Complaint	**Points**
My sweating is never noticeable and never interferes with my daily activities	1
My sweating is tolerable but sometimes interferes with my daily activities	2
My sweating is barely tolerable and frequently interferes with my daily activities	3
My sweating is intolerable and always interferes with my daily activities	4
HDSS Score of 1: mild; HDSS Score of 2: moderate; HDSS Score of 3–4: severe.	

All the patients were advised to evacuate their bladder before surgery. All patients received general anesthesia with third G. cephalosporins antibiotics on induction. The procedure was done using double lumen endotracheal tube to allow single lung ventilation. All patients were placed in the thoracotomy position (lateral decubitus) & the patients were secured to the table by straps along the hip. The ipsilateral arm was elevated and abducted to clear the axillary region. All the operations were performed using a standard thoracoscopic technique with three 5 mm ports inserted. The first side approached was always the right side.

Clamping of the appropriate endotracheal tube lumen was done by anaethesia team to help lung collapse. Pneumothorax was achieved with a Verrus needle using CO2 insufflation with about two liters at a pressure of 6-7 mmHg, and then the 3 ports were introduced. The first port (for 0 degree 5 mm Camera) was introduced in the 5th intercostal space, at mid-axillary line followed by insertion of port in 3rd or 4th spaces at anterior axillary line and another port in 5th or 6th space at anterior axillary line under complete vision. The instruments used were a grasper, a Maryland & a hook with monopolar cautery as an energy source.

The lung's pleural surface was initially inspected to exclude lung injuries during needle or ports insertion. The head of the operating table was tilted up to allow the lung to fall out off the field helping more visualization. Then orientation to local anatomy was commenced by identification of the second rib & subclavian vessels & followed by identification of the sympathetic chain. The sympathatic chain and ganglions were readily visualized running vertically along the neck of the ribs and were clearly seen through the parietal pleura or were identified by pushing the parietal pleura against the rib head area by an instrument.

In group A patients, incision of the parietal pleura above the 3rd ganglion was done (usually just below the 3rd rib) and opening of pleura. The ganglion was identified between both ribs, grasped, transected below; above 4th rib,

dissected, transected above; below 3rd rib & excised. Cauterization of the rami communicants at the curve of the corresponding 3rd rib was done and any bleeding was secured. After checking for haemostasis, an under-water seal inter-costal chest tube was inserted under vision till the end of the procedure, the endotracheal clamp was removed to allow the lung to inflate under vision and then the thoracoscope was withdrawn gradually. In group B patients, the same previous steps were done at the level of 4th ganglion just below the 4th rib.

The patients were then repositioned and the procedure was repeated on the contralateral (left) side with the same ganglion level in each patient. An under-water seal inter-costal chest tube was inserted under vision till just before the removal of endotracheal tube by anaesthesia. After repositioning the patients to the neutral supine position, both intercostals tubes were removed and skin was closed.

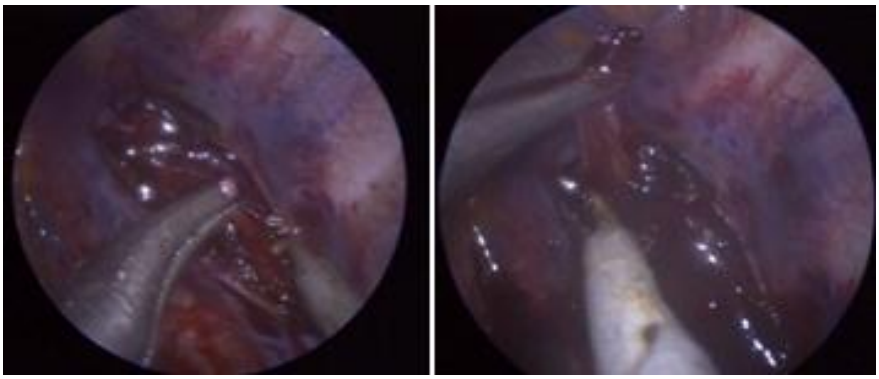

Fig. 1: Excision of Lt. T3 ganglion in one of our group A patients.

Operation time (from skin to skin) in minutes was noted and recorded together with intraoperative complications as major bleeding and lung or other important structure injury. All the patients were discharged home on the next day after adequate analgesia & chest x-ray confirming absence of significant pneumothorax except for one patient who developed Rt sided moderate pneumothorax that required prolonged hospital stay (4 days) till improvement. Follow up visits were scheduled at 10 days, 1 month, 6 months and 1 year. All patients were encouraged to return to their previous lifestyle without limitations.

Patients came for follow-up in the outpatient clinic after 10 days for removal of stitches and to assess the efficacy of the procedure (defined as: subjective clinical improvement on HDSS) & the early post operative complications as residual pneumothorax in one or both sides & surgical emphysema. At the 1 month visit, the patients were seen for assessment of early post operative side effects. The patients were seen after 6 months and after one year to assess late side effects, symptoms recurrence and patient satisfaction.

All the data from both groups were collected and compared. Statistical analysis was performed using SPSS software version 17(IBM SPSS Statistics 17.0.3; IBM SPSS, 2009). Students t-test was applied for continuous variables while Chi-square and fisher exact tests were applied for categorical variables. All $P < 0.05$ were considered to be significant.

RESULTS

The study was completed on 40 patients (26 males and 14 females) whose age ranged from 18 to 39 years (mean 24.4 ± 3.8). All were medically free except for; two patients had type 2 DM and one had bronchial asthma. Bilateral TS was successfully completed in all patients with no need to convert to open thoracotomy for either organ or vascular injury or severe adhesions. There were no serious intraoperative events, as massive hemorrhage, arrhythmia or sudden cardiac arrest. Only very thin adhesions were encountered in 3 cases that were easily managed. In 2 cases, a contusion of parietal lung surface was observed and in 5 cases significant bleeding

during the operation occurred (mostly from the intercostal veins) and was successfully controlled. The mean operating time was 74 min. ± 18 min. (range: 55-125 min.). The mean operating time for each side was 23 min. ± 7 min. (range: 15-50 min.). There was no statistically significant difference among both groups regarding age, sex, mean operative time & operative events: see table 2.

All the 40 patients noticed improvement of sweating in both hands at the day of surgery. 17 patients out of the 40 developed early post operative pneumothorax, 16 cases of them were minimal to mild & clinically insignificant (14 unilateral & 2 bilateral) and was managed at home with chest physiotherapy, and only one patient developed moderate Rt. pneumothorax that necessitated 4 days hospital stay till significant improvement. Surgical emphysema on either side was noticed in 6 patients that were detected both clinically & radiologically; 2 of them occurred with mild pneumothorax. All cases were self limiting. There was no statistically significant difference among both groups regarding both complications.

Patients were seen after 10 days for removal of stitches. Chest x-ray done to all patients showed improvement of pneumothorax and surgical emphysema in affected patients with no new occurrences. There wasn't any complaint suggestive of Horner's syndrome in all patients. There was one case of delayed mild pleural effusion and it was managed conservatively without aspiration.

Table 2: Patients' demographics, operative & early postoperative events and their significance (all insignificant):

		Group A (20)	**Group B (20)**	**P-value**
Age		25.1 ± 4.0	23.7 ± 3.5	0.246‡
Sex	Males	14 (70%)	12 (60%)	0.507*
	Females	6 (30%)	8 (40%)	
Mean operative time		77 ± 15	72 ± 14	0.282‡
Lung surface contusion		2 (10%)	0 (0%)	0.487**
Adhesions		2 (10%)	1 (5%)	1.0**
Significant bleeding		2 (10%)	3 (15%)	1.0**
Pneumothorax		10 (50%)	7 (35%)	0.337*
Surgical emphysema		2 (10%)	4 (20%)	0.66**
Delayed pleural effusion		0 (0%)	1 (5%)	1.0**

Data expressed as number and (percent), mean±SD ‡ Student t test, *Chi-square test, **Fisher exact test

When asked about their hands sweating, all the 40 patients noticed marked improvement of their condition based on the evaluation using the HDSS as all patients showed improvement from score 3-4 to score 1-2. In group A patients, 17 patients noticed bilateral complete hand dryness, while 3 noticed partial wetness in either one or both hands. In group B patients, 10 patients noticed bilateral complete hand dryness, while 10 noticed partial wetness in either one or both hands.

At 1 month visit, when asked about other body sites sweating, 18 patients in group A noticed increased sweating at other body sites as trunk, back &/or thighs, while 12 patients in group B noticed increased sweating at other body sites. Only 2 patients in group A noticed increased facial sweating in relation to spicy food.

At 6 months and then at one year visits, all the patients were assessed for palmar dryness, sweating recurrence, severity of compensatory sweating, gustatory sweating & degree of satisfaction with surgery including causes of dissatisfaction. Recurrence was considered when patients had sweating & felt severe discomfort similar to that before surgery in spite of improved symptoms of sweating. In all patients, no recurrence of PPH occurred during the assessed period.

In group A patients, till the end of the first year, 15 patients (75%) continued to have complete hand dryness, while 5 noticed that mild sweating appeared in one hand at least during

summer time and with long-time fist clenching (they considered it normal hands). Among the 15 patients with complete dryness, 2 patients (10%) complained of severe dryness to the degree of using emollient cream frequently & one of them felt severely distressed as he was unable to perform his daily activities with ease. In group B patients, 7 patients (35%) continued to have complete hand dryness, while 10 noticed that mild sweating appeared in one hand at least during summer time and with long-time fist clenching (they considered it normal). No one complained of severe distressing dryness. Three patients complained that their hands were still sweaty but better than before surgery and this was not much distressing; HDSS: 2. Complete hand dryness in group A patients (75%) when compared to group B (35%) was statistically significant (P: 0.011). Severe distressing dryness occurred only in group A & sweaty hands occurred only in group B, but such findings among both groups in both cases were statistically insignificant (P: 0.487 & 0.23 respectively).

As regard CS, 19 of group A patients (95%) noticed increased sweating at other body sites (trunk, back and / or thighs) that increased again with summer time. 4 of them (20%) stated that their body sweating was severe to the degree that they needed frequent daily change of clothes (3 during summer only; HDSS: 3 & 1 all year; HDSS: 4). While in group B, 12 patients (60%) noticed increased sweating at other body sites, and in only 1 patient (5%) it was severe to the degree of daily frequent change of clothes (during summer; HDSS: 3). Any degree of CS in group A patients when compared to group B was statistically significant (P: 0.02), while, severe CS among both groups (although more in group A) was insignificant (P: 0.34).

When asked about gustatory sweating, 3 patients in group A (15%) noticed increased facial sweating in relation to spicy food, while it was not recorded in group B, but these results were statistically insignificant (P: 0.23).

As regard patients' satisfaction, all the 40 patients were asked to choose their degree of satisfaction among 4 choices: markedly satisfied, satisfied, equivocal (neutral/can't decide) and dissatisfied (see table 4). In group A patients, 4 were markedly satisfied (20%) and 11 were satisfied (55%). Three patient were neutral (15%) because of severe hand dryness and severe CS, while 2 patients were dissatisfied (10%) and regretted having the surgery; one because of whole year CS and the other because of severe disabling hand dryness associated with summer time severe CS. In group B patients, 12 were markedly satisfied (60%) and 6 were satisfied (30%). Two patients were neutral (10%), one because of incomplete hand dryness (still sweaty hands in spite of surgery) and the other because of summer time severe CS. And no patients expressed their dissatisfaction with the procedure.

When calculating overall satisfaction, 75% of group A patients were satisfied by any degree and 10% were dissatisfied, while in group B patients 90% were satisfied by any degree and no patients were dissatisfied. Marked satisfaction in group B patients (60%) when compared to group A (20%) was statistically significant (P: 0.01), yet, overall satisfaction and dissatisfaction among both groups were statistically insignificant (P: 0.07 and 0.487 respectively).

Table 3: Results and side effects at one year and their significance.

		Group A (20) N (%)	**Group B (20) N (%)**	**P-value**
Hand dryness/wetness	Normal hand Sensation	5 (25%)	10 (50%)	0.102*
	Complete dryness	15 (75%)	7 (35%)	0.011* S
	Sweaty hands	0 (0%)	3 (15%)	0.23**
Severe distressing dryness		2 (10%)	0 (0%)	0.487**
Compensatory sweating	Any degree	19 (95%)	12 (60%)	0.02** S
	severe	4 (20%)	1 (5%)	0.34**
Gustatory sweating		3 (15%)	0 (0%)	0.23**

‡ Student t test, *Chi-square test, **Fisher exact test. S: significant

Table 4: Degrees of satisfaction and their significance.

	Group A (20) N (%)	**Group B (20) N (%)**	**P-value**
Markedly satisfied	4 (20%)	12 (60%)	0.01* S
Satisfied	11 (55%)	6 (30%)	0.11*
Overall Satisfaction (any grade)	15 (75%)	18 (90%)	0.07*
Neutral/can't decide	3 (15%)	2 (10%)	1.0**
Dissatisfied	2 (10%)	0 (0%)	0.487**

‡ Student t test, *Chi-square test, **Fisher exact test. S: significant

DISCUSSION

TS has been used for over 20 years for the treatment of PPH (31). With deeper understanding of the disease & surgery complications, the aim of treatment has shifted from simply resolving the symptoms to maximizing the QoL [(24)].

CS continues to be the most common side effect of TS. The reported incidence of this complication varies throughout the literature. This variability is probably due to the differences in surgical technique and classification of CS. The mechanisms of CS have not been fully elucidated[(6,9,13)]. Hands dryness is also a common complication of TS, and if severe, this complication can make patients feel even worse than they did before the operation [(32)]. In severe cases, the skin on the hands develops cracks, and regular application of hand cream is required to keep the hands moist [(24)]. Gustatory sweating has been rarely reported in old literature and was particularly related to spicy or acidic foods [(33)]. The pathogenesis of gustatory sweating is still unknown. It has been reported that it could result from the sprouting of vagal nerve fibers into the transected sympathetic chain[(34)]. Patient satisfaction is the most important way to evaluate the success of TS. CS severely diminishes the postoperative patient's QoL [(35)]. The incidence and severity of CS were regarded as the most important indicators of operative success in most studies [(24)].

Traditionally, T2 ganglion was viewed as the key pathway for the hands and TS was done at T2–T3 or T2–T4 levels to eliminate the symptoms of PPH [(27, 36)]. But T2 interruption caused dry hands & face denervation and increased the risk of postoperative complications (CS & gustatory sweating) [(24)].

Various surgical methods have been attempted to reduce the rates of CS. Many authors felt that the frequency & severity of CS were correlated to both the level & extent of resection. The more ganglions excised, especially those including T2, the greater the incidence of severe CS symptoms[(27)]. Many studies limited the extent of resections to a single level & noticed reduction in the incidence of severe CS; others found that staying away from T2 ganglion may limit CS[(19,37)]. A more recent anatomic study by Gray showed that the preganglionic fibers to the arm originate mostly from the third to the sixth spinal segments and the third and fourth segments were considered as main lesions [(38)]. In recent years, TS at a single level rather than at multiple levels became increasingly preferred [(24)]. T3 and T4 are the frequently used denervation levels for PPH, and result in fairly good results and a varying incidence of postoperative complications [(39)]. At present, there is still some debate about the optimal transection level for PPH [(24)].

In an attempt to reduce side effects, the technique of TS has been modified to minimize the extent of surgery from resection of ganglion to ablation, transection, clipping and even differential dissection like ramicotomy. Now sympathicotomy that transects the inter-ganglion fibers above the ribs but does not resect the ganglions is the most popular method worldwide[(27)]. However in our study, we have chosen to do sympathectomy by excision of the ganglion of the required level (ganglionectomy) for fear of nerve regeneration and recurrence and we didn't face any recurrence of preoperative symptoms in all our 40 patients in both study groups after at least one year of follow up.

In our study, 40 patients underwent TS and all complications related to thoracoscopy were mild and self limiting and comparable to most literature worldwide. We had no major intraoperative event as cardiac arrest, arrhythmias or major organ or vascular injury. Intra-

operatively, we encountered 3 cases of mild adhesions (7.5%), 2 cases of lug surface contusion (5%) and significant intercostal bleeding in 5 cases (12.5%). Postoperatively, we managed 17 cases of pneumothorax (32.5%); only one of them was clinically significant (2.5%), 6 cases of surgical emphysema (15%) and 1 case of delayed pleural effusion (2.5%). Neither of these intra-operative events or early post-operative complications was significant among our both study groups.

CS by any degree was the most common long term side effect in our study and was noticed in 19 patients in the T3 group (95%) and in 12 in the T4 group (60%); significantly higher in the T3 group. While severe CS (HDSS: 3 or 4) occurred in 4 patients in the T3 group (20%) and occurred in only one patient in the T4 group (5%) but this was not significant statistically mostly due to the relatively small sample size. In the study by Liu et al in 2009[27] that compared T3 and T4 sympathicotomy, 48 patients out of the 68 (70.6%) in the T3 group and 39 patients out of the 73 (53.4%) in the T4 group had CS by any degree. Moderate to severe CS occurred in 9 patients in the T3 group (13.2%) and in 2 patients in the T4 group (2.7%).

In the study by Kim et al in 2010 [39] that also compared T3 and T4 sympathicotomy, 46 patients out of the 56 (82.1%) in the T3 group and 11 patients out of the 63 (17.4%) in the T4 group had CS by any degree. Moderate to severe CS occurred in 6 patients in the T3 group (10.7%) and in 2 patients in the T4 group (3.2%). While in the study by Ishy et al in 2011 [40] who compared 20 patients in each group, 20 patients in the T3 group (100%) and 15 patients in the T4 group (75%) suffered from CS and only one patient in each group (5%) suffered from moderate to severe CS. In Kavakli et al study in 2012 [41], 8 patients out of 43 (18.6%) in the T3 group had CS and it was not recorded in any of the 46 patients (0%) in the T4 group. In the study by Ellatif et al in 2014[42] that again compared sympathicotomy in 129 patients (T3) with 145 patients (T4), 96 patients in the T3 group (74.4%) and 41 patients in the T4 group (28.3%) reported CS, while moderate to severe CS was encountered in 28 (21.7%) of the T3 patients and in 17 (11.7%) of the T4 patients.

Troublesome hands over-dryness in our study was noticed in 2 patients in T3 group (10%) and was not noticed in the T4 group (0%), but this was statistically insignificant. In Ellatif et al study in 2014 [42], 11 patients out of the 129 in the T3 group complained of hands over-dryness (8.5%), while one patient out of the 145 in the T4 group (0.7%) and this was statistically significant. While in the study by Kim et al in 2010[39], hands over-dryness occurred in 3 patients of the 56 in the T3 group (5.4 %) and didn't occur in the T4 group (0%) but this was insignificant like ours. In Liu et al. 2009[27], hands over-dryness was noticed in 8 patients out of the 68 in the T3 group and in 1 patient out of the 73 in the T4 group.

The gustatory sweating in our study was noticed in 3 patients in T3 group (15%) and was not noticed in the T4 group (0%), but this was statistically insignificant. This was similar to the study by Kim in 2010[39], in which gustatory sweating occurred in 5 patients of the 56 in the T3 group (8.9%) and didn't occur in the T4 group (0%). While in the study by Mahdy et al in 2008[43] gustatory sweating occurred in 5 patients of the 20 in the T3 group (25%) and occurred in 1 patient in the T4 of the 20 in the T4 group (5%).

At the end of the first year, we assessed patients' level of satisfaction with the procedure by asking each patient to choose among 4 choices: markedly satisfied, satisfied, neutral (can't decide) and dissatisfied (regretted having the surgery). Marked satisfaction was significantly higher in the T4 group (12 patients; 60% in T4 group and 4 patients; 20% in the T3 group). Overall satisfaction was more in the T4 group (15 patients in T3 group; 75% and 18 patients in T4 group; 90%) but not statistically significant. Dissatisfaction and regret was noticed only in the T3 group (2 patients; 10%) but again not statistically significant.

In Ellatif et al study in 2014[42], 128/129 (99.2%) in the T3 group and 143/145 (98.6%) in the T4 group were satisfied. In the study by Kim et al in 2010[39], 55/56 (98.2%) in the T3 group and 61/63 (96.8%) in the T4 group were satisfied. While in Liu et al study in 2009 [27], all patients (100%) in both groups were satisfied. In the study by Mahdy et al in 2008 [43], 15/20 (75%) in the T3 group and 20/20 (100%) of the T4 group were satisfied. Most studies that compared T3 & T4 showed comparable non significant overall satisfaction rates.

So in our study that compared T3 and T4, T4 level TS achieved comparable results with lower

rates of postoperative complications (CS, dry hands & gustatory sweating) and equally high cure and even higher satisfaction rates. However; this study has some limitations: It is a single-center study and its size is not large enough to show statistically significant difference in some aspects. The follow up time was only one year which may be not sufficient to evaluate sweating recurrence properly.

CONCLUSION

Based on the results of this study, given the increased levels of marked & overall satisfaction rates, T4 TS is the level most recommended for treating PPH, as it serves the purpose in decreasing excessive palmar sweating while providing mildly moist rather than dry fissured palms. Also, it reduces the occurrence & severity of CS and results in more patient satisfaction with minimal regret and better QoL. However, larger sized studies are required to confirm these results.

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