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Comparative study between uniportal and triportal VATS in the management of primary spontaneous pneumothorax

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ABSTRACT

Background: Nowadays, video-assisted thoracoscopic surgery (VATS) is the management of choice for primary spontaneous pneumothorax (PSP). This prospective study was designed to address the efficacy and the possible advantages of using uniportal VATS when compared with triportal VATS in management of PSP. *Method:* A total of 80 VATS procedures were randomly done for PSP. 40 procedures were performed with uniportal VATS compared to 40 procedures performed with triportal VATS in the management of PSP. Patients were followed-up for 12 months postoperatively. *Results:* Both uniportal and triportal VATS have the same efficacy in managing PSP. There is no difference between both techniques regarding postoperative bleeding and air-leak (p=1.0). Uniportal VATS has a shorter operative time (66.32±3.46 vs 72.95±6.08 minutes, p<0.001). Adding another port wasn't needed in uniportal VATS, while it was needed in 6 (15%) patients in triportal VATS group (p=0.026). Uniportal VATS has a statistically significant difference regarding postoperative pain duration (3.80±1.04 vs 4.32±0.47 days, p=0.005), early postoperative pain scale by visual analogue pain scale (1.77±1.02 vs 2.37±1.25, p=0.022), chest tube duration (4.85±0.57 vs 5.07±0.26 days, p=0.029), postoperative paresthesia (0.05±0.22 vs 0.90±0.74, p<0.001), postoperative hospital stay (5.45±0.50 vs 5.87±0.75 days, p=0.004), and better cosmesis (2.35±0.62 vs 1.92±0.65 on scale 1-3, p=0.004). *Conclusions:* Uniportal VATS is a safe and a feasible approach in management of PSP. Uniportal VATS is a good alternative to triportal VATS due to its efficacy in decreasing postoperative pain, paresthesia, total duration of hospital stay and in providing better cosmesis.

Keywords: pneumothorax, uniportal, triportal, VATS, bullectomy.

1. INTRODUCTION

Primary spontaneous pneumothorax is one of the common thoracic surgical problems. PSP usually affects young tall thin adult males. In PSP, air accumulates in the pleural space due to rupture of subpleural blebs or bullae which are usually located in the apex of the lungs. Patients with primary spontaneous pneumothorax could be managed by insertion of chest tube

drain alone. However, approximately 50% of patients that received chest tube insertion show recurrent pneumothorax. Therefore, blebectomy or bullectomy with pleurodesis are the gold standard in the management of PSP and they are considered as the most effective management in decreasing the postoperative recurrence rate (Sawada et al., 2005). Open thoracotomy had been used initially for PSP before the wide application of video-assisted thoracoscopic surgery (VATS). Many studies described the superiority of VATS when compared to open thoracotomy in management of PSP because it had been proved to be less invasive, with lower costs and better cosmetic results (Nachira et al., 2018).

Many recent reports had proved the feasibility and effectiveness of uniportal VATS in management of PSP when compared to the triportal VATS (Nachira et al., 2018; Masmoudi et al., 2017; Bertolaccini et al., 2017). After reviewing the literature, there are few reports comparing the effectiveness and the possible advantages of using uniportal VATS compared to VATS in the surgical treatment of PSP. However, most of these studies included only a few numbers of patients diagnosed ascases of PSP. So, this study was designed to compare the role of uniportal VATS and triportal VATS in the surgical treatment of PSP by using a larger number of those patients with a larger number of variables that were used in this comparative study.

2. METHODS

From October 2018 to August 2020, a prospective study was designed with a total number of 80 patients with PSP after approval from the Institutional Ethics Committee (IRB # 3846 / 16 – 8 – 2018). Informed consent wasalways obtained from all patients. Patients were also randomly divided into 2 groups: uniportal VATS group with a total number of 40 patients, and triportal VATS group with a total number of 40 patients. All patients had completed the study and were followed-up for 12 months postoperatively either in outpatient clinic or by telephone to rule out recurrence of pneumothorax.

Inclusion criteria

Indications for surgery were the following:
Persistent air-leak for more than 7 days
Recurrent pneumothorax
Previous contralateral pneumothorax
Presence of a bulla or subpleural blebs on computed tomography
Presence of severe lung collapse or tension pneumothorax

Exclusion criteria

Patients over 40 years old
Patients with previous lung resection on the ipsilateral side
Patients requiring simultaneous surgery on both sides

Surgical technique

All patients underwent the procedures under general anesthesia with double lumen endotracheal tube for one-lung ventilation. All patients were placed in lateral decubitus for blebectomy or bullectomy to excise the dystrophic or damaged areas of pulmonary parenchyma. After localization of the target blebs or bullae, all lung areas are inspected to rule out the possibility of finding any additional bullae. Special attention is paid to the superior segment of the lower lobes. Blebs or bullae are resected using endostaplers. A bubble test was always done in all cases to ensure an air-tight parenchymal excision. Thereafter, mechanical pleurodesis was done in all cases by performing partial parietal pleural abrasions extending from the dome of the pleura to the 8th or 9th ribs.

For uniportal VATS, a 2-4 cm incision is done in the fourth or fifth intercostal space at the anterior axillary line. However, patients who have a chest drain inserted preoperatively, the chest drain incision was used as the uniportal access, and it may be extended for 1-2 cm if needed. A wound protector is always inserted. After performing blebectomy or bullectomy followed bythe bubble test and mechanical pleurodesis, intercostal nerve block is performed by injecting Ropivacaine under direct thoracoscopic inspection of the intercostal nerves from the 2nd till the 8th intercostal spaces. A 24-28 Fr chest drain is inserted and fixed in the most posterior side of that incision (Figure 1).

For triportal VATS, a 1 cm incision is done in the 7th intercostal space at the midaxillary line to useit as a camera port. The 2nd incision is 1 cm and made in the fourth or fifth intercostal space at the anterior axillary line to be used as the stapler port. The 3rd incision is 5 mm and is done in the fourth or fifthintercostal space at the scapular line to be used for the introduction of the

endoscopic grasper (Figure 2). After performing blebectomy or bullectomyand after the bubble test and mechanical pleurodesis, intercostal nerve block is performed by injecting Ropivacaine. A 24-28 Fr chest drain is inserted through the camera port (Ismail et al., 2017).

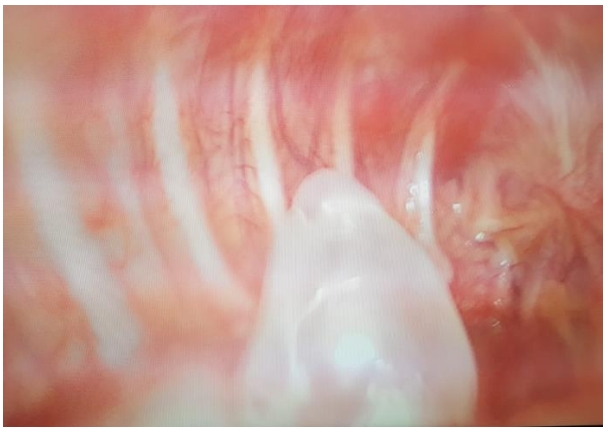

Figure 1 RT apical bulla seen during rt uniportal bullectomy procedue.

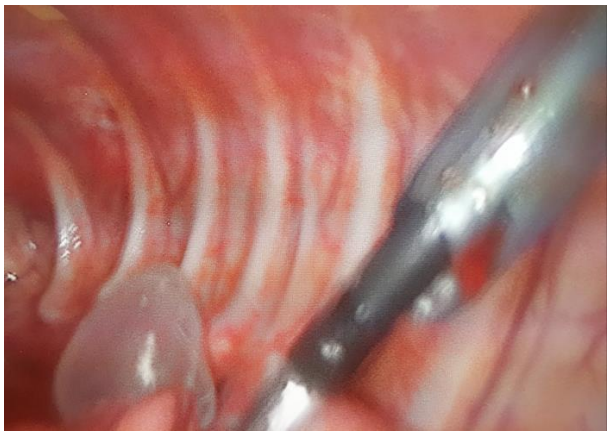

Figure 2 Lt apical bulla seen during lt triportal bullectomy procedure

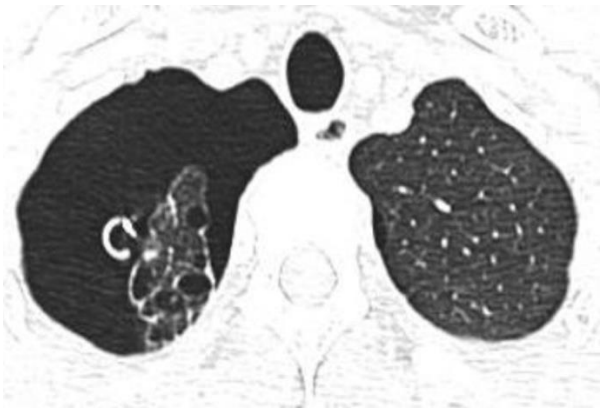

Figure 3 Axial CT image showing multiple rt apical bullae with rt ICT for rt pneumothorax.

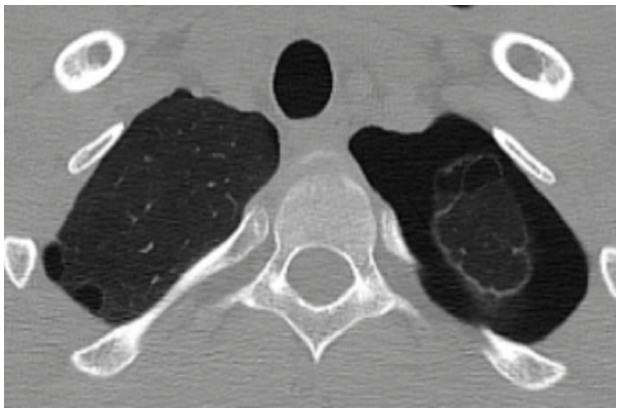

Figure 4 Axial CT image showing multiple bilateral apical bullae with lt pneumothorax.

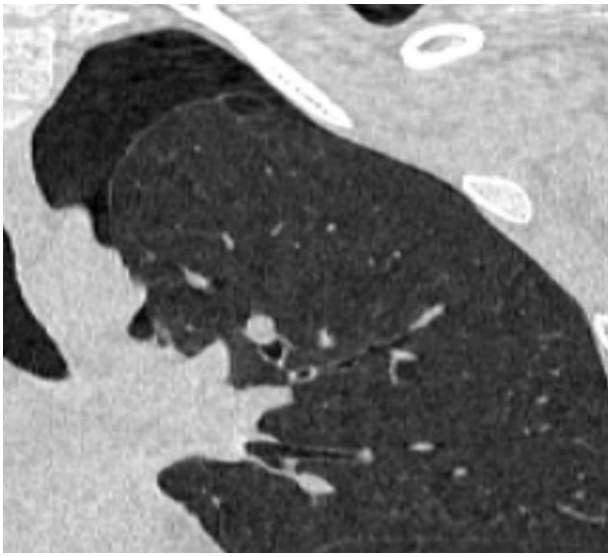

Figure 5 Coronal CT image showing lt apical bulla and lt pneumothorax.

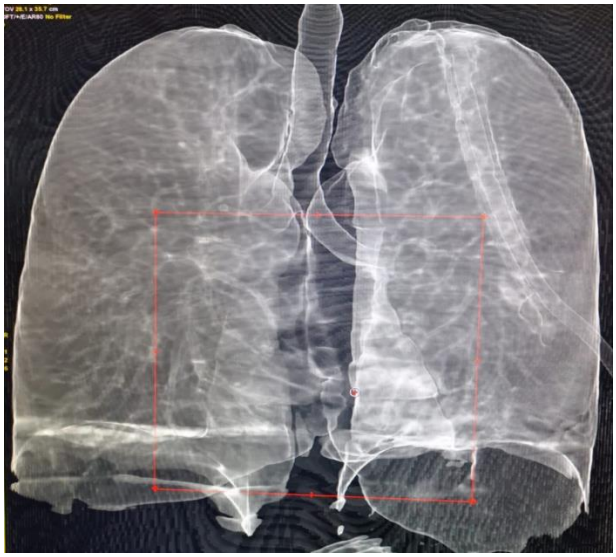

Figure 6 3D reformatting CT image showing lt apical irregularies denoting multiple lt apical bullae. Lt lung volume is decreased due to lt pneumothorax. ICT is seen insitu. A small rt apical bulla is also suggested.

Data collection

An informed consent was always obtained from all patients before the procedure for the operation and for using their data for this study. Preoperative data included age, gender, history of smoking and bronchial asthma, preoperative FEV_1% and FVC%, history of pneumothorax for the first time, history of recurrent pneumothorax, history of previous contralateral pneumothorax, preoperative insertion of chest drain, presence of persistent air-leak and preoperative length of hospital stay. Preoperative CT (Computed Tomography) evaluation of the underlying lung parenchymal disease is routinely done for all patients (Figure 3-6).

Intraoperative data included the operative time, type of the operation whether apical blebectomy or bulectomy or other resections not involving lung apex, approximate resected volume, performing mechanical pleurodesis, the need to add an additional port for both uniportal and triportal VATS and the rate of actual conversion of VATS to thoracotomy.

Postoperative data included the postoperative complications in the form of bleeding or persistent air-leak, the postoperative pain duration, analgesic and painkiller duration, early postoperative pain scale (after 48 hours) by visual analogue pain scale (VAS) (Table 1), duration of chest drain, pain scale after chest drain removal (VAS), total length of postoperative hospital stay, postoperative paresthesia which was evaluated after the 1st month postoperatively, cosmetic results and incidence of recurrence of pneumothorax throughout the full follow-up period (12 months).

Table 1 The visual analogue scale (VAS) used for evaluation of postoperative pain

Score	Description
0	No pain at rest or during movement
1	Mild pain during movement but no pain at rest
2	Mild pain at rest but moderate during movement
3	Moderate pain at rest but severe during movement
4	severe pain at rest and during any movement

Statistical analysis

The statistical analysis was calculated using SPSS 20.00 software (Chicago, IL, USA). Continuous variables were always expressed as means and standard deviations. Pearson χ^2 test and Fischer's exact test were utilized to compare categorical variables. Student's *t*-test was used to compare continuous variables. A P value less than 0.05 was considered statistically significant.

3. RESULTS

Patients' characteristics and preoperative data for both the uniportal and triportal VATS groups were summarized in Table 2. There were no statistically significant differences between both groups regarding preoperative data in terms of age, gender, history of smoking and bronchial asthma, preoperative FEV_1% and FVC%, history of pneumothorax for the first time, history of recurrent pneumothorax, history of previous contralateral pneumothorax, preoperative insertion of chest drain, presence of persistent air-leak and preoperative length of hospital stay.

Table 2 Patients' characteristics and preoperative data

Variable	Uniportal VATS (N=40)	Triportal VATS (N=40)	P value
Age	25.47±3.78	24.85±3.49	0.445
Gender (male)	33(82%)	35(87%)	0.531
Smoking	16(40%)	18(45%)	0.651
Asthma	1(2%)	2(5%)	0.556
Preoperative FEV_1 %	84.70±6.94	86.32±5.88	0.262
Preoperative FVC%	86.77±6.16	86.92±8.22	0.927
First time PTX	14(35%)	15(37%)	0.816
Recurrent PTX	18(45%)	21(52%)	0.502
Previous contralateral PTX	15(37%)	13(32%)	0.639
Preoperative chest drain	31(77%)	31(77%)	1.000
Persistent air-leak	19(47%)	23(57%)	0.370
Preoperative hospital stay (days)	2.77±0.69	2.82±0.54	0.723

VATS: video-assisted thoracoscopic surgery; PTX: pneumothorax; FEV_1: forced expiratory volume in the first second; FVC: forced vital capacity

Intraoperative data in both groups were summarized in Table 3. The operative time in uniportal VATS was shorter (66.32±3.46 minutes in uniportal VATS vs 72.95±6.08 minutes in triportal VATS group) and this operative time showed a significant difference between both groups (p<0.001). Adding another port wasn't needed in uniportal VATS, while it was needed in 6 (15%) patients in triportal VATS group (p=0.026). There were not any statistically significant differences between both groups regarding type of the procedure whether apical blebectomy or bulectomy or other resections not involving lung apex, approximate resected volume, performing mechanical pleurodesis and the rate of actual conversion of VATS to thoracotomy.

Table 3 Intraoperative data in both groups

Variable	Uniportal VATS N=40	Triportal VATS N=40	P value
Operative time (minutes)	66.32±3.46	72.95±6.08	<0.001
Apical blebectomy / bullectomy	33(82%)	34(85%)	0.762
Other resections	7(17%)	6(15%)	0.762
Approximate resected volume(mm^3)	24.57±5.96	23.95±4.41	0.596
Pleurodesis	40(100%)	40(100%)	1.000
Adding additional port	0(0%)	6(15%)	0.026
VATS conversion to thoracotomy	0(0%)	0(0%)	1.000

VATS: video-assisted thoracoscopic surgery

Postoperative data in both groups were summarized in Table 4. There was no mortality reported in this study. Uniportal VATS has a statistically significant difference regarding postoperative pain duration (3.80±1.04 days in uniportal VATS group vs 4.32±0.47 days in triportal VATS group, p=0.005), duration of postoperative pain management (3.10±0.91 days in uniportal VATS group vs 3.55±0.67 days in triportal VATS group, p=0.014), early postoperative pain scale by visual analogue pain scale (1.77±1.02 in uniportal VATS group vs 2.37±1.25 in triportal VATS group, p=0.022), chest drain duration (4.85±0.57 days in uniportal VATS group vs 5.07±0.26 days in triportal VATS group, p=0.029), pain scale after chest drain removal (VAS scale) (1.25±0.77 in uniportal VATS group vs 1.62±0.49 in triportal VATS group, p=0.012), postoperative paresthesia (0.05±0.22 in uniportal VATS group vs 0.90±0.74 in triportal VATS group, p<0.001), postoperative hospital stay (5.45±0.50 days in uniportal VATS group vs 5.87±0.75 days in triportal VATS group, p=0.004), and better cosmesis (2.35±0.62 in uniportal VATS group vs 1.92±0.65 in triportal VATS group on scale 1-3, p=0.004). There were not any statistically significant differences between both groups regarding postoperative complications in form of reoperation for persistent air-leak, postoperative bleeding, or late recurrence of pneumothorax.

Table 4 Postoperative data in both groups

Variable	Uniportal VATS N=40	Triportal VATS N=40	P value
Postoperative bleeding	0(0%)	0(0%)	1.000
Reoperation for persistent air-leak	0(0%)	0(0%)	1.000
Postoperative pain duration (days)	3.80±1.04	4.32±0.47	0.005
Duration of postoperative pain management (days)	3.10±0.91	3.55±0.67	0.014
Early * postoperative pain scale (VAS scale)	1.77±1.02	2.37±1.25	0.022
Chestdrain duration (days)	4.85±0.57	5.07±0.26	0.029
Pain scale after chest tube removal (VAS scale)	1.25±0.77	1.62±0.49	0.012
Postoperative paresthesia#	0.05±0.22	0.90±0.74	<0.001
Postoperative hospital stay (days)	5.45±0.50	5.87±0.75	0.004
Cosmetic results (1-3 scale)	2.35±0.62	1.92±0.65	0.004
Postoperative recurrence of PTX	0(0%)	0(0%)	1.000

VATS: video-assisted thoracoscopic surgery; PTX: pneumothorax; VAS: visual analogue scale (0-4 scale).
*: after 48 hours postoperatively; #: Level of paresthesia: 0(null), 1(mild), 2(moderate), 3(severe).

4. DISCUSSION

Over the last decades, management of PSP has developed markedly from open surgery to VATS. The lower invasiveness, provided by conventional VATS compared to open thoracotomy, has achieved great advantages in improving patient recovery through decreasing chest drain duration, postoperative pain, and total hospital stay (Goto et al., 2014). Moreover, this already decreased invasiveness of the conventional VATS had been minimized by using the uniportal VATS (Sawada et al., 2005). However, the majority of the studies that evaluated the exact role of uniportal VATS in management of PSP were retrospective, unfocused, and designed with small numbers of patients and with few comparison parameters which finally resulted in many conflicting results (Masmoudi et al., 2017).

This study had revealed same results obtained by some authors who had reported the improved postoperative outcomes in forms of decreasing operative time, postoperative bleeding, and postoperative pain (Masmoudi et al., 2017; Qin et al., 2015; Kim, 2017). On the other hand, some authors reported the opposite results (Yang et al., 2013). Moreover, some authors reported some limitations during surgical exposure and faced some technical problems during uniportal VATS rather than during triportal VATS (Kim et al., 2015). This may be attributed to manipulation of many endoscopic instruments through the small incision of the single port which may lead to interference between the camera and the endoscopic instruments, which in turn may result in increasing the operative time (Igai et al., 2014; Yoshikawa et al., 2021).

In our study, conversion from uniportal VATS to triportal VATS or to thoracotomy was not needed. Moreover, there was also no need to convert triportal VATS to thoracotomy. Chen et al., (2011) reported that the rate of conversion from uniportal VATS to triportal VATS for hemostasis was infrequent in contrast to the increased rate of conversion of triportal VATS to thoracotomy for hemostasis. Our study demonstrated a significant increase ($p= 0.026$) in the need to add additional port in triportal VATS group which was due to presence of dense adhesions between the lung and chest wall. Dense adhesions were managed by uniportal VATS without the need to add any additional ports. These findings were also reported by other authors (Nachira et al., 2018). We confirmed the previous findings that addressed the early patient discharge of uniportal VATS group compared to triportal VATS group which may be due to less postoperative pain, early patient mobilization and faster recovery (Nachira et al., 2018; Masmoudi et al., 2017). It should be noted that throughout our study the postoperative pain control and chest drain removal protocol were constant in all patients and during the overall duration of the study in both groups.

In our study, VAS score after 48 hours postoperatively was 1.77±1.02 in uniportal VATS group vs 2.37±1.25 in triportal VATS group ($p=0.022$). These results were supported by Nachira et al., (2018) who reported a statistically significant lower VAS score in uniportal VATS group ($p<0.001$). Chen et al., (2011) compared VAS score after 48 hours postoperatively between uniportal VATS and triportal VATS. Their mean VAS score was statistically insignificant ($p>0.05$) opposite to the results obtained by our study. These good results related to postoperative pain may be attributed to the site of the port incision in uniportal VATS which is in a more anterior location, where the intercostal space is much wider, in addition to the routine use of wound protector instead of using 3 trocars in triportal VATS. All these factors will protect the intercostal tissue and preserve the neurovascular bundle from any possible injury or compression.

Consequently, pain management together with postoperative pain control and analgesic intake werealso significantly affected by the decreased postoperative pain. This coincided with the results obtained by other previous studies (Nachira et al., 2018; Masmoudi et al., 2017). In regard to postoperative pain, it is of extreme importance to mention that both groups have the same pleurodesis technique in form of pleural abrasions so as to avoid any statistical bias that might be obtained if different pleurodesis techniques were applied during this study. After 1 month postoperatively, we had clear results denoting a lower incidence of development of postoperative paresthesia detected in the uniportal VATS group than the triportal VATS group ($p<0.001$). These findings could be interpreted by the presence of additional 2 incisions used in thetriportal VATS which could theoretically expose those patients to a 3-fold risk of possible intercostal nerve damage when compared to a single incision. These results were supported by Sihoe et al., (2004) who reported 52.9% of cases with paresthesia after triportal VATS. The lower incidence of postoperative paresthesia in uniportal VATS was also described by many other previous studies (Nachira et al., 2018; Masmoudi et al., 2017; Jutley et al., 2005). This postoperative paresthesia may be severe and difficult to treat. This point must be taken into consideration before making any additional incision which may predispose to this paresthesia (Jutley et al., 2005).

Our results revealed that scars of uniportal VATS has a significant better cosmesis than triportal VATS ($p=0.004$). A single small scar is a clear advantage of uniportal VATS in management of PSP which usually affects young adults. This seems to be a very important issue, especially in the management of a benign disease affecting young adults. These results were demonstrated by Masmoudi et al., (2017) who concluded that 85% of patients of uniportal VATS group had a satisfactory result with their scars. Moreover, Nachira et al., (2018) documented better cosmetic results in uniportal VATS group than in triportal VATS group

($p<0.001$). In our study, recurrence rate in both groups was 0%. This makes any results about recurrence difficult to justify. We thought thisvery low recurrence rate might be larger with longer period of postoperative follow-up and with studying larger number of patients. However, there are many reports which concluded no significant difference in recurrence rate between uniportal and triportal VATS (Chen et al., 2012; Tsuboshima et al., 2015). Recurrence rate in the literature ranges from 0% to10% for uniportal VATS, and from 1.8% to 11.7% for triportal VATS (Masmoudi et al., 2017).

5. CONCLUSION

Uniportal VATS is a practical and a safe approach in management of PSP. Uniportal VATS offers a good alternative approach to triportal VATS due to its effectiveness in decreasing postoperative pain, paresthesia, and total duration of hospital stay and in providing better cosmetic results.

Acknowledgement

We thank the participants who were all contributed samples to the study.

Author Contributions

Ehab F. Salim and Gaser A. Ali conceived and designed the study; both Ehab F. Salim and Gaser A. Ali performed the procedures; Ehab F. Salim analyzed the data; Gaser A. Ali shared in discussing the results; and Ehab F. Salim wrote the paper. All authors read and approved the final manuscript.

Informed consent

Written & Oral informed consent was obtained from all individual participants included in the study. Additional informed consent was obtained from all individual participants for whom identifying information is included in this manuscript.

Ethical approval

Study was approved by the institutional ethical approval committee in August 2018 (IRB # 3846 / 16 – 8 – 2018).

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This study has not received any external funding.

Conflict of interest

The authors declare that there are no conflicts of interest.

Data and materials availability

All data associated with this study are present in the paper.

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