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Review

Minimally invasive esophagectomy: Lateral decubitus vs. prone positioning; systematic review and pooled analysis

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ABSTRACT

The uptake of minimally invasive esophagectomy (MIE) has increased vastly over the last decade, with proven short-term benefits over an open approach. The aim of this pooled analysis was to compare clinical outcomes of Minimally Invasive Esophagectomy (MIE) performed in the prone and lateral decubitus positions.

A systematic literature search (2000–2015) was undertaken for publications that compared patients who underwent MIE in the lateral decubitus (LD) or prone (PR) positions. Weighted mean difference (WMD) was calculated for the effect size of LD positioning on continuous variables and Pooled odds ratios (POR) for discrete variables.

Ten relevant publications comprising 723 patients who underwent minimally invasive esophagectomy were included; 387 in the LD group and 336 in the PR group. There was no significant difference between the groups in terms of in-hospital mortality, total morbidity, anastomotic leak, chylothorax, laryngeal nerve palsy, average operative time, and length hospital stay. LD MIE was associated with a non-significant increase in pulmonary complications (POR = 1.65; 95% C.I. 0.93 to 2.92; P = 0.09), and significant increases in estimated blood loss (WMD = 36.03; 95% 14.37 to 57.69; P = 0.001) and a reduced average mediastinal lymph node harvest (WMD = −2.17; 95% C.I. −3.82 to −0.52; P = 0.01) when compared to prone MIE.

Pooled analysis suggests that prone MIE is superior to lateral decubitus MIE with reduced pulmonary complications, estimated blood loss and increased mediastinal lymph node harvest. Further studies are needed to explain performance-shaping factors and their influence on oncological clearance and short-term outcomes.

Contents

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1. Introduction

The incidence of esophageal cancer is rapidly increasing, and this disease annually affects 482,300 people worldwide [1]. Currently the main curative option for esophageal cancer is surgical resection and this traditionally requires an open approach, commonly involving a thoracotomy. Transthoracic open esophagectomy carries a high risk of pulmonary complications that are reported to occur in up to 57% of cases [2]. However, in recent years the development of minimally invasive esophagectomy (MIE) has been associated with a significant reduction in post-operative pulmonary complications, as well as reducing hospital stay, and improving short-term quality of life when compared to the open-approach [3]. Moreover from the surgeon's perspective, the ergonomics conferred by a thoracoscopic approach and in particular the prone position, have improved the operative field exposure [4].

Minimally invasive esophagectomy was originally performed with the patient in the lateral decubitus position but the use a prone approach was first described in 1994 [5]. This position is felt to be associated with reduced pulmonary complications compared to the lateral decubitus approach and there is a large body of evidence that prone ventilation improves pulmonary function in other conditions such as acute respiratory distress syndrome [6]. Following traditional transthoracic esophagectomy ventilating patients in a prone position has been shown to improve arterial oxygenation [7] and this effect is believed to be due to improved recruitment of collapsed alveoli, as well as improved lung perfusion and reduction in intrapulmomary shunt [8,9].

The uptake of MIE has increased vastly over the last decade [10]. However, there has been no definitive consensus as to whether this procedure should be performed with the patient in the lateral decubitus or prone position [11] adding to the observed wide variability in the performance of MIE [12]. A systematic review of the literature between 1994 and 2010 showed no convincing evidence that prone position is superior to lateral decubitus although most authors comment that the prone position is associated with superior surgical ergonomics and theoretically offers a number of physiological benefits [11]. Further clinical studies were recommended to examine patient outcomes. With more clinical studies being available, we carried out this review and pooled analysis to compare clinical outcomes of MIE performed in the prone and lateral decubitus positions to examine which of these approaches offers the best patient outcome.

2. Methods

2.1. Literature search strategy

An electronic literature search was undertaken using Embase, Medline, and Web of Science databases up to January 2015. The search terms 'thoracoscopy', 'laparoscopy', 'esophagectomy', 'prone', 'decubitus' and Medical Subject Headings (MeSH) 'laparoscopy' (MeSH), 'thoracoscopy' (MeSH) and 'esophagectomy' (MeSH), were used in combination with the Boolean operators AND or OR. Two authors (TW and SRM) performed the electronic search independently in January 2015. The electronic search was supplemented by a hand-search of published abstracts from meetings of the Society of Academic and Research Surgery, the International Society for Diseases of the Esophagus, the European Society for Diseases of the Esophagus, Digestive Disease Week, the Association of Upper Gastro-Intestinal Surgeons of Great Britain and Ireland, Society of American Gastro-Intestinal and Endoscopic Surgeons and European Association of Endoscopic Surgeons from 2005 to 2014. The reference lists of articles obtained were also searched to

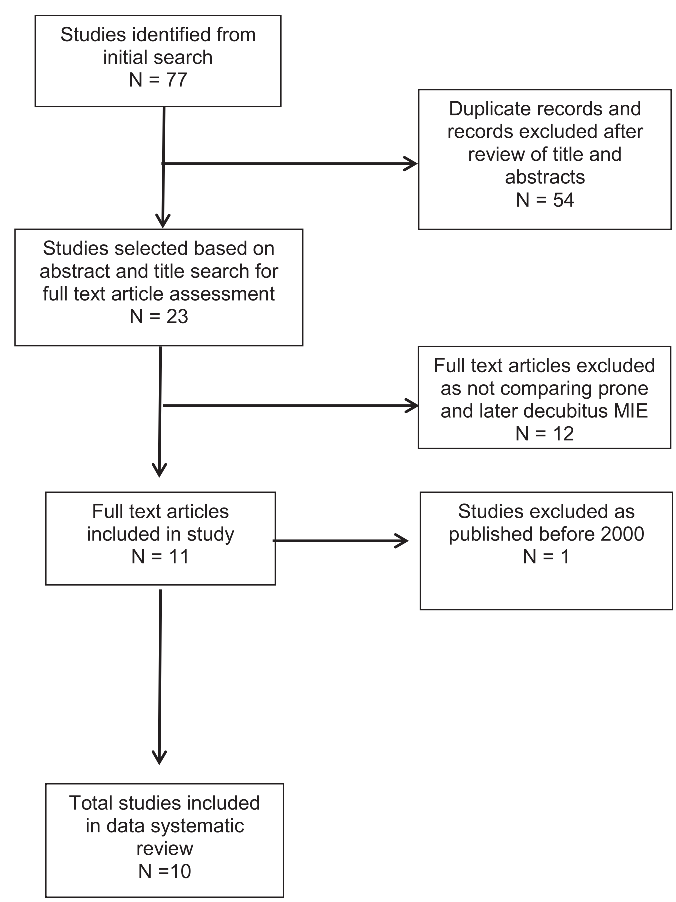

Fig. 1. PRISMA flow chart describing literature search strategy.

Table 1
Patient demographics for the studies included in the pooled analysis.

Author	Patient number		Age (years)		Male gender		Location (U/M/L)		Stage (Tis/I/II/III/IV)	
	LD	Prone	LD	Prone	LD	Prone	LD	Prone	LD	Prone
Fabian 2008 [14]	11	21	63.7 (44–82)	62.4 (46–86)	10 (91%)	13 (62%)	0/3/8	2/2/17	1/4/3/3/0	5/7/6/3/0
Feng 2012 [15]	41	52	61.7 ± 9.7	60.1 ± 7.7	29 (70%)	34 (65%)	6/28/7	4/38/10	2/4/30/4/1	1/5/36/7/3
Kuwabara 2010 [16]	58	22	64.5	64.5	53 (91%)	20 (91%)	4/29/25	3/6/13	9/9/19/21/0	1/8/5/8/0
Lin 2013 [17]	90	60	59.8 ± 9.1	57.7 ± 8.6	65 (72%)	45 (75%)	4/68/18	8/38/14	0/20/31/39/0	0/14/22/24/0
Noshiro 2010 [18]	34	43	64 (50–80)	63 (54–83)	27 (79%)	37 (86%)	5/19/10	5/20/18	0/13/5/14/1	0/15/6/19/3
Shen 2014 [19]	32	35	60.9 ± 8.4	60.5 ± 7.3	24 (75%)	26 (74%)	5/20/7	6/22/7	0/6/7/19/0	0/6/8/21
Song 2009 [20]	15	7	–	–	–	–	–	–	–	–
Tanaka 2014 [21]	59	51	63.1 ± 8.7	64.5 ± 7.1	48 (81%)	42 (82%)	10/25/24	11/20/20	0/21/19/15/4	0/14/15/21/1
Yatabe 2013 [22]	24	24	61 ± 8	68 ± 6	18 (75%)	20 (83%)	1/15/8	5/15/4	0/7/6/8/3	0/7/7/7/3
Zou 2013 [23]	23	21	63.2 ± 4.4	60.1 ± 10.5	18 (78%)	19 (90%)	3/15/5	2/8/11	0/2/8/11/2	0/4/9/8/0

LD – Lateral Decubitus.
Continuous variables presented as median (range) or mean ± standard deviation.

Table 2
Operative details and length of stay.

Author	Operative time (min)		Thoracic operative time (min)		Estimated blood loss (ml)		Mediastinal lymph node harvest		Left recurrent laryngeal nerve lymph node harvest		Length of stay (days)	
	LD	Prone	LD	Prone	LD	Prone	LD	Prone	LD	Prone	LD	Prone
Fabian 2008 [14]	375 (255–600)	330 (210–530)	123 (93–150)	85.6 (55–138)	85 (50–150)	65 (20–10)	14.6 (6–22)	15.5 (7–30)	–	–	9 (7–33)	10 (7–52)
Feng 2012 [15]	217 ± 32	202 ± 21	77 ± 17	67 ± 20	142 ± 49	123 ± 56	8.9 ± 4.9	11.6 ± 4.0	1.3 ± 1.1	3.3 ± 2.7	17.4 ± 12.5	11.4 ± 6.8
Kuwabara 2010 [16]	205	196	–	–	101	50	18	20.5	4	4	22	16.5
Lin 2013 [17]			120 (110–150)	120 (110–120)	150 (100–200)	150 (150–200)	15 ± 6	14 ± 6	3 ± 2	3 ± 2	13 (11–16)	14 (12–16)
Noshiro 2010 [18]	562 ± 82	572 ± 69	272 ± 58	307 ± 66	295 ± 416	142 ± 87	26.8 ± 11.0	27.0 ± 9.1	5.4 ± 5	6.1 ± 3.9	–	–
Shen 2014 [19]			87 ± 24	68 ± 22	67 ± 16	89 ± 18	15.4 ± 3.3	18.2 ± 2.9	–	–	10.8 ± 4.3	9.4 ± 3.6
Song 2009 [20]	–	–	191 ± 42	154 ± 41	–	–	–	–	–	–	–	–
Tanaka 2014 [21]	493 ± 106	530 ± 64	294 ± 57	310 ± 48	405 ± 329	105 ± 107	25 ± 12	31 ± 11	–	–	29 ± 17	27 ± 19
Yatabe 2013 [22]	576 ± 82	640 ± 85	151 ± 42	247 ± 50	474 ± 279	209 ± 146	–	–	–	–	35 ± 15	23 ± 16
Zou 2013 [23]	312.2 ± 48.6	318.1 ± 32.5	–	–	258.7 ± 92.5	193.1 ± 66.5	18.2 ± 5.9	22.6 ± 6.7	–	–	–	–

LD – Lateral Decubitus.
Continuous variables presented as median (range) or mean ± standard deviation.

identify further relevant citations. Abstracts of the articles identified by the electronic search were scrutinized by two of the authors (TW and SRM) to determine their suitability for inclusion in the pooled analysis.

Publications were included if they were randomized or case-matched controlled or comparative studies in which patients underwent minimally invasive esophagectomy in the lateral decubitus (LD) or prone (PR) positions, and published from 2000 to 2014 (to ensure the outcomes were a reflection of current practice). Studies were excluded if they were non-comparative or investigated open esophagectomy or a hybrid position between prone and lateral decubitus, or published before 2000.

2.2. Outcome measures

Primary outcome measures were in-hospital mortality and early morbidity (defined as a complication developing within 30 days of the procedure and occurring as a direct result of surgery).

Table 3
Post-operative complications.

Author	In-hospital mortality		Morbidity		Anastomotic leak		Pulmonary complications		Chylothorax		Laryngeal nerve injury	
	LD	Prone	LD	Prone	LD	Prone	LD	Prone	LD	Prone	LD	Prone
Fabian 2008 [14]	0	1 (5%)	6 (55%)	10 (48%)	2 (18%)	1(4%)	3 (27%)	4 (19%)	1 (9%)	0	1 (9%)	0
Feng 2012 [15]	1 (2%)	0	20 (49%)	23 (44%)	9 (22%)	4 (8%)	4 (10%)	5 (10%)	–	–	1 (2%)	3 (6%)
Kuwabara 2010 [16]	2 (3%)	0	26 (44%)	6 (27%)	15 (26%)	3 (14%)	17 (29%)	1 (5%)	2 (3%)	0	20 (34%)	5 (22%)
Lin 2013 [17]	1 (1%)	1 (2%)	30 (33%)	22 (37%)	3 (3%)	5 (8%)	10 (11%)	7 (12%)	2 (2%)	2 (3%)	9 (10%)	5 (8%)
Noshiro 2010 [18]	0	1 (2%)	12 (35%)	15 (35%)	0	3 (7%)	5 (15%)	5 (11.6%)	3 (9%)	1 (2%)	6 (18%)	6 (14%)
Shen 2014 [19]	0	0	10 (31%)	9 (26%)	3 (9%)	3 (9%)	4 (13%)	2 (6%)	–	–	2 (6%)	3 (9%)
Song 2009 [20]	–	–	–	–	–	–	–	–	–	–	–	–
Tanaka 2014 [21]	0	0	27 (46%)	24 (47%)	4 (7%)	5 (10%)	8 (14%)	6 (12%)	0	2 (4%)	13 (22%)	14 (27%)
Yatabe 2013 [22]	0	1 (4%)	14 (58%)	6 (25%)	4 (17%)	3 (13%)	9 (38%)	1 (4%)	–	–	5 (21%)	2 (8%)
Zou 2013 [23]	0	0	3 (13%)	3 (14%)	2 (9%)	2 (10%)	–	–	–	–	1 (4%)	1 (5%)

LD – Lateral Decubitus.
Continuous variables presented as median (range) or mean ± standard deviation.

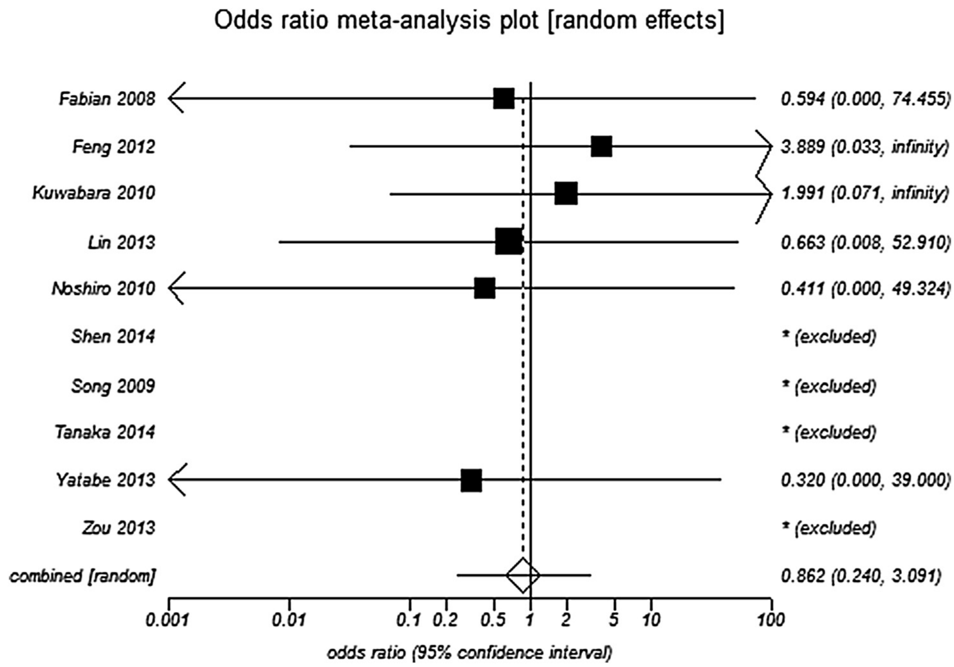

Fig. 2. Forrest plot showing no significant difference between the groups in in-hospital mortality (POR = 0.86; 95% C.I. 0.24 to 3.09; P = 0.82).

Secondary outcome measures were anastomotic leak, pulmonary complications (included pneumonia, atelectasis, aspiration and pulmonary embolus), chylothorax, laryngeal nerve palsy/injury, total operative time, thoracic operative time, estimated blood loss, length of hospital stay and lymph node harvest (mediastinal and left laryngeal nerve).

2.3. Statistical analysis

Data from eligible trials was entered into a computerised spreadsheet for analysis. Statistical analysis was performed using StatsDirect 2.5.7 (StatsDirect, Altrincham, UK). Weighted mean difference (WMD) was calculated for the effect size of lateral decubitus (LD) positioning on continuous variables. Pooled odds ratios (POR) were calculated for the effect of lateral decubitus (LD) on discrete variables. All pooled outcome measures were determined using random-effects models as described by DerSimonian Laird [13]. Heterogeneity among trials was assessed by means of the Cochran's Q statistic, a null hypothesis in which $P < 0.05$ is taken to indicate the presence of significant heterogeneity [14]. The Egger test was used to assess the funnel plot for significant asymmetry, indication of possible publication or other biases.

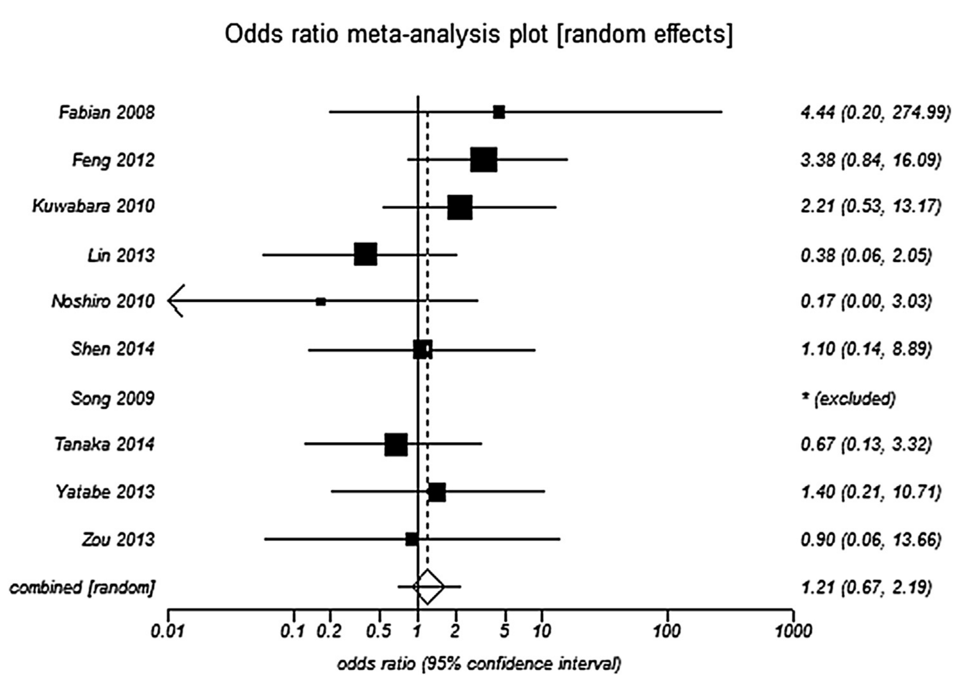

Fig. 3. Forrest plot showing no significant difference between the groups in anastomotic leak (POR = 1.21; 95% C.I. 0.67 to 2.19; P = 0.52).

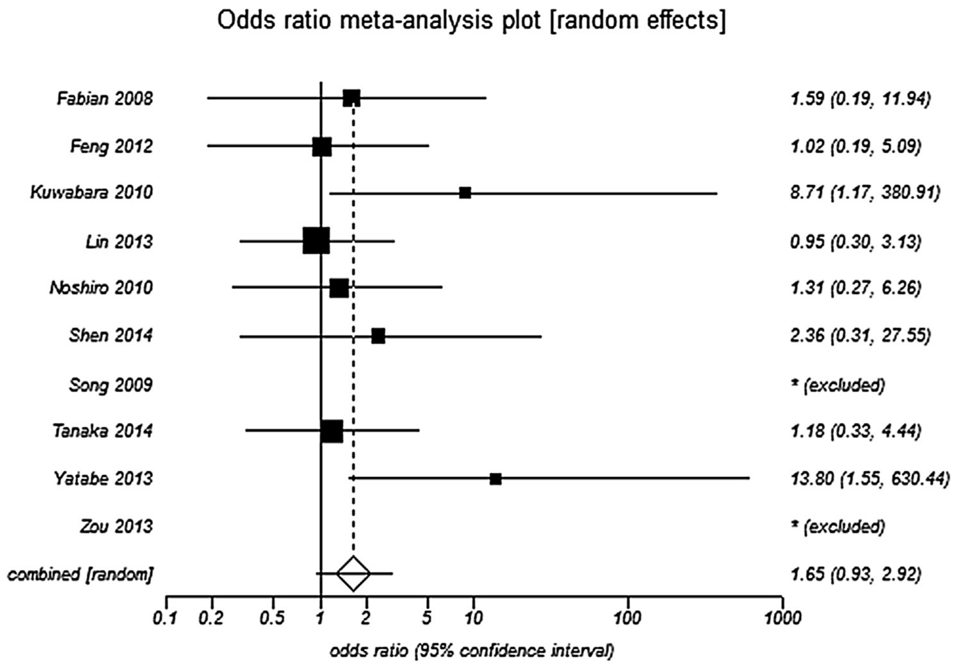

Fig. 4. Forrest plot showing a non-significant increase in pulmonary complications in the LD group (POR = 1.65; 95% C.I. 0.93 to 2.92; P = 0.09).

3. Results

The literature search (Fig. 1) identified ten relevant publications that were included in this pooled analysis [15–24]. One study was a randomized controlled trial with the remaining studies being non-randomized comparative studies. In total 723 patients who underwent minimally invasive esophagectomy were included; 387 in the LD group and 336 in the PR group. Table 1 describes the distribution of patient age, gender, medical comorbidities and tumor characteristics, which were equally distributed between the groups. Tables 2 and 3 describe the results from the individual studies for the clinical outcome measures evaluated in this pooled analysis.

3.1. Primary outcome measures

3.1.1. In-hospital mortality

(Fig. 2) The incidence of in-hospital mortality was reported in nine studies [15–20,22–24], and was 1.1% and 1.2% in the LD and PR groups respectively. Pooled analysis showed no significant difference between the groups (POR = 0.86; 95% C.I. 0.24 to 3.09; P = 0.82). There was no evidence of statistical heterogeneity (Cochran Q = 1.77; P = 0.88; I^2 = 0%) or bias (Egger = −0.30; P = 0.95).

3.1.2. Early morbidity

The incidence of early morbidity was reported in nine studies [15–20,22–24], and was 39.8% and 35.9% in the LD and PR groups respectively. Pooled analysis showed no significant difference between the groups (POR = 1.21; 95% C.I. 0.88 to 1.66; P = 0.25). There was no evidence of statistical heterogeneity (Cochran Q = 6.69; P = 0.57; I^2 = 0%) or bias (Egger = 1.60; P = 0.17).

3.2. Secondary outcome measures

3.2.1. Anastomotic leak (Fig. 3)

The incidence of anastomotic leak was reported in nine studies [15–20,22–24] and was 11.3% and 8.8% in the LD and PR groups respectively. Pooled analysis showed no significant difference between the groups (POR = 1.21; 95% C.I. 0.67 to 2.19; P = 0.52). There was no evidence of statistical heterogeneity (Cochran Q = 9.22; P = 0.32; I^2 = 13.3%) or bias (Egger = −1.12; P = 0.48).

3.2.2. Pulmonary complications (Fig. 4)

The incidence of pulmonary complications was reported in seven studies [15–20,22], and was increased in the LD compared to PR group (17.6% vs. 10.1%). Pooled analysis showed a non-significant increase in pulmonary complications in the LD group (POR = 1.65; 95% C.I. 0.93 to 2.92; P = 0.09). There was no evidence of statistical heterogeneity (Cochran Q = 8.66; P = 0.28; I^2 = 19.1%), however there was some evidence of bias (Egger = 3.62; P = 0.003).

3.2.3. Chylothorax

The incidence of chylothorax was reported in five studies [15,17–19,22], and was 3.2% and 2.5% in the LD and PR groups respectively. Pooled analysis showed no significant difference between the groups (POR = 1.32; 95% C.I. 0.41 to 4.25; P = 0.64). There was no evidence of statistical heterogeneity (Cochran Q = 4.06; P = 0.40; I^2 = 1.4%) or bias (Egger = 0.63; P = 0.82).

3.2.4. Laryngeal nerve palsy/injury

The incidence of laryngeal nerve palsy or injury was reported in nine studies [15–20,22–24] and was 10.8% and 10.3% in the LD and PR groups respectively. Pooled analysis showed no significant difference between the groups (POR = 1.07; 95% C.I. 0.64 to 1.78; P = 0.80). There was no evidence of statistical heterogeneity (Cochran Q = 4.18; P = 0.84; I^2 = 0%) or bias (Egger = 0.60; P = 0.33).

3.2.5. Total operative time/thoracic operative time

The average total operative time with range or standard deviation was reported in six included studies [15,16,19,22–24], and the average thoracic operative time was reported in eight studies [15,16,18–23]. There was no significant difference between the groups in total average operative time (WMD = −4.61; 95% C.I. −32.16 to 22.93; P = 0.74). There was evidence of significant

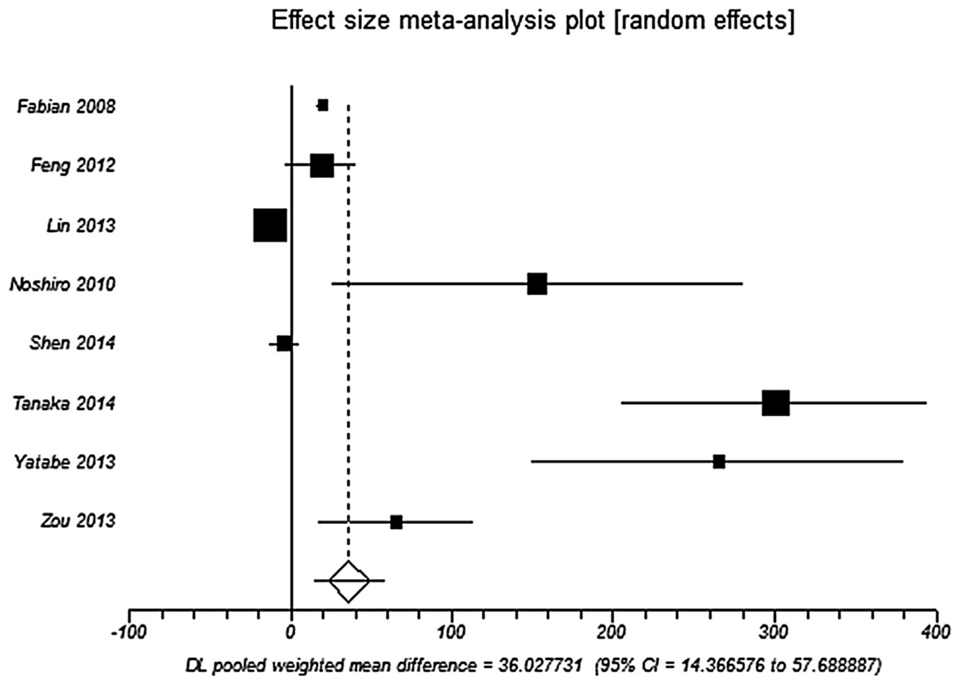

Fig. 5. Forrest plot showing a significantly increased estimated blood loss in the LD group (WMD = 36.03; 95% 14.37 to 57.69; P = 0.001).

statistical heterogeneity (Cochran Q = 71.42; P < 0.0001; I^2 = 93%) and bias (Egger = −5.24; P = 0.008). Furthermore there was no significant difference between the groups in thoracic operative time (WMD = −5.85; 95% C.I. −24.95 to 13.25; P = 0.55). There was evidence of significant statistical heterogeneity (Cochran Q = 633.4; P < 0.0001; I^2 = 98.9%), however there was no significant bias (Egger = 2.12; P = 0.64).

3.2.6. Estimated blood loss (Fig. 5)

Eight studies reported the average estimated blood loss with range or standard deviation [15,16,18–20,22–24] Pooled analysis demonstrated a significantly increased estimated blood loss in the LD group (WMD = 36.03; 95% 14.37 to 57.69; P = 0.001). There was significant evidence of statistical heterogeneity (Cochran Q = 335.28; P < 0.0001; I^2 = 97.9%), however there was no significant bias (Egger = 5.00; P = 0.14).

3.2.7. Length of hospital stay

Six studies reported average length of hospital stay with range or standard deviation [15,16,18,20,22,23]. There was no significant

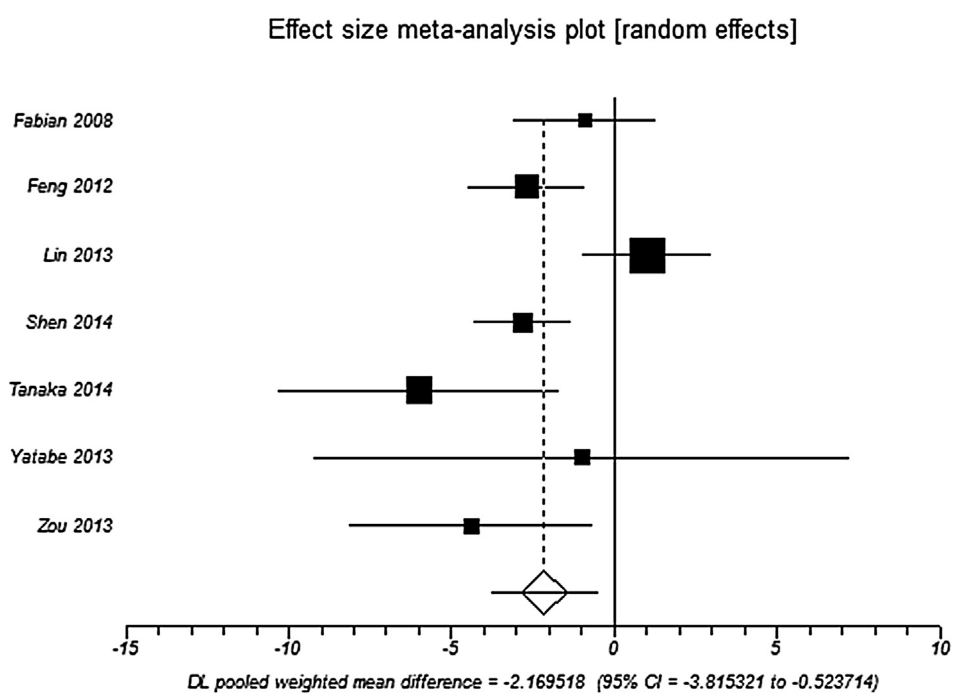

Fig. 6. Forrest plot showing the average mediastinal lymph node harvest was significantly reduced in the LD group (WMD = −2.17; 95% C.I. −3.82 to −0.52; P = 0.01).

difference between the groups in average length of hospital stay (WMD = 0.99; 95% C.I. −1.80 to 3.79; P = 0.49). There was evidence of significant statistical heterogeneity (Cochran Q = 41.77; P < 0.0001; I^2 = 88%), however there was no evidence of statistical bias (Egger = 1.25; P = 0.45).

3.2.8. Mediastinal lymph node harvest (Fig. 6)

Seven studies reported the average mediastinal lymph node harvest with range or standard deviation [15,16,18–20,22,24]. The average mediastinal lymph node harvest was significantly reduced in the LD group (WMD = −2.17; 95% C.I. −3.82 to −0.52; P = 0.01). There was evidence of significant statistical heterogeneity (Cochran Q = 16.31; P = 0.01; I^2 = 63.2%), however there was no evidence of statistical bias (Egger = −0.75; P = 0.66). Three studies reported average lymph node harvest from tracing the left recurrent laryngeal nerve [16,18,19]. There was no significant difference between the groups in left recurrent laryngeal lymph node harvest (WMD = −0.91; 95% C.I. −2.44 to 0.61; P = 0.24). There was evidence of significant statistical heterogeneity (Cochran Q = 14.25; P = 0.001; I^2 = 86%), and there was insufficient evidence to allow calculation of statistical bias.

4. Discussion

The present study suggests that prone MIE was better than lateral decubitus in terms of a reduction in pulmonary complications, average estimated blood loss and an increased average mediastinal lymph node harvest. Importantly there was no significant difference between the groups in terms of in-hospital mortality, early morbidity, anastomotic leak, chylothorax, laryngeal nerve palsy, operative time and length of hospital stay.

A major drive for performing esophagectomy in a certain position is the technical difficulty of executing component tasks of the operation. The performance of mid and lower mediastinal dissection is easier in the prone position as the lung will fall out of the operating field without much retraction allowing the surgeon to face the posterior mediastinum for direct dissection of the esophagus from the aorta and pericardium. This may account for the reduced blood loss and possibly the increase in lymph node count with the ease of technical performance. On the other hand, the dissection of left recurrent laryngeal nerve behind the trachea would be more easily performed in the lateral decubitus that allows better retraction on the trachea. In this position, there is a need for lung retraction to dissect the lower and mid mediastinum and hence, the insertion of an increased number of wider access ports. This lung manipulation itself may account for the increase in pulmonary complications. The optimal position for performing thoracoscopic esophagectomy with superior mediastinal lymphadenectomy remains unclear from the present published literature, which consists mainly of isolated case series with surgeons biased by their individual preferences [25,26]. The team at Keio University, Tokyo has combined the benefits of both prone and lateral decubitus scenarios in terms of patient positioning through a tilted table [27].

The present study showed that prone position is associated with an increased number of dissected thoracic lymph nodes compared with lateral decubitus. The prone position may allow better dissection along the aorta, pericardium and carina while the lateral decubitus would allow easier dissection along the left recurrent laryngeal nerve. It is difficult to numerically quantify the significant value of lymphadenectomy along left recurrent laryngeal nerve due to the small number of studies specifying the number of dissected lymph nodes and the narrow variability margin of the actual number of those nodes. Nevertheless, it is a surgical dogma that the quality of surgical dissection as reflected by lymphadenectomy will result in a better disease control and ultimately long term survival.

Luketich et al. [28] published the largest series of MIE to date with over 1000 cases in a lateral decubitus position with a low complication and mortality rate (1.68%). Palanivelu et al. [29] similarly published the largest series of MIE in the prone position including 130 patients with a low incidence of complications and a similarly low mortality rate (1.54%). The reduction in pulmonary complications seen with prone MIE is likely to multi-factorial. Palanivelu performed prone MIE with a single lumen endotracheal tube often with left lung ventilation and intermittent right lung ventilation [29]. This partial right lung ventilation reduces the venous shunt effect, and furthermore in the prone position the functional residual capacity is greater. These two factors ensure the ventilation perfusion ratio is well maintained therefore avoiding hypercarbia and hypoxia. Additionally, intermittent ventilation of the right lung results in opening up of alveoli to prevent postoperative atelectasis, which is not possible in the lateral decubitus position with the use of a double-lumen endotracheal tube and complete deflation of one lung [29].

A further advantage to prone MIE was seen with a reduction in the estimated blood loss compared to lateral decubitus MIE. In prone MIE the esophagus and dissection plane are located to the north of the laparoscopic picture, ensuring that blood drips to the south and away from the operating field. This prevents the blood from pooling in the dissection field and hence the operating surgeon can identify and ligate any bleeding points with greater efficiency; reducing overall blood loss from the procedure. This factor may also be responsible for the increased mediastinal lymph node harvest seen in the prone MIE group, as blood will drip away from the operating area ensuring better visualization of the field of dissection.

Proponents of lateral decubitus MIE have suggested that in event of severe bleeding that would require conversion to open thoracotomy; this is most easily done in the lateral position, due to familiarity with this approach. However this is a rare event, with prone MIE demonstrating a very similar complication profile to lateral decubitus MIE. Furthermore identification of the bleeding point may be more easily identified and controlled thoracoscopically in the prone position as described above, therefore reducing the requirement for conversion in this circumstance.

There are important limitations inherent with this type of pooled analysis that must be taken into account when interpreting the results presented here. The majority of the studies included were comparative in nature with only one randomized controlled trial included; therefore there are several important confounding variables, which may not have been equally distributed between the groups that may have influenced the results. Important outcomes that were not evaluated adequately to allow pooled analysis included postoperative pain and long-term survival. Given the differences seen in lymph node harvest between the groups an important area for future investigation will be disease recurrence and long-term survival associated with these two approaches to MIE. In this present pooled analysis we were also unable to account for utilization of neoadjuvant chemoradiotherapy, which can scar tissue planes making thoracic dissection more challenging and this is an especially relevant factor during MIE. Furthermore there was variation in the definition of complications, which is an important limitation associated with pooled analysis of any individual case series.

Prone and lateral decubitus positioning for MIE have similar operative safety as suggested by mortality and early morbidity rate. Pooled analysis suggests that prone MIE is superior to lateral decubitus MIE with reduced pulmonary complications, estimated blood loss and increased mediastinal lymph node harvest. Although a good surgical practice is informed by high level of evidence from randomized controlled clinical trials, it is unlikely that a standard randomized trial will be conducted to answer this question because a superiority trial would be difficult to perform with surgeons asked to perform esophagectomy in a position that they may have already biases against. Nevertheless, a practice-based randomization that allows every surgeon to do his or her preferred method may be an alternative option. Short of performing such randomization in a large-scale pragmatic trial, a human factors approach for error analysis of technical performance and prospective short-term outcome studies may confirm the benefits of a certain position. We believe that ergonomic studies using Observational Clinical Human Reliability Analysis techniques [30] as well as qualitative analysis methodology will explain performance-shaping factors in each position and direct the surgical community to best practice.

5. Conclusion

Pooled analysis suggests that prone MIE is superior to lateral decubitus MIE with reduced pulmonary complications, estimated blood loss and increased mediastinal lymph node harvest. Further studies are needed to explain performance-shaping factors and their influence on oncological clearance and short-term outcomes.

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Conflicts of interests

None.

Authorship statement

We confirm all authors made substantial contributions to:

1. Conception and design of the study, or acquisition of data or analysis and interpretation of data.
2. Drafting the article or revising it critically for important intellectual content
3. Final approval of the manuscript submitted.

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