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Does minimally invasive oesophagectomy provide a benefit in hospital length of stay when compared with open oesophagectomy?

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Summary

A best evidence topic in thoracic surgery was written according to a structured protocol. The question addressed was: 'in patients undergoing oesophagectomy, does a minimally invasive approach convey a benefit in hospital length of stay (LOS), when compared to an open approach?' A total of 647 papers were identified, using an *a priori* defined search strategy; 24 papers represented the best evidence to answer the clinical question. The authors, journal, date, country of publication, patient group, study type, relevant outcomes and key results are tabulated. Of the studies identified, data from two randomized controlled trials were available. The first randomized study compared the use of open thoracotomy and laparotomy versus thoracoscopy and laparoscopy. Those undergoing minimally invasive oesophagectomy (MIO) left hospital on average 3 days earlier than those treated with the open oesophagectomy (OO) technique ($P = 0.044$). The other randomized trial, which compared thoracotomy with thoracoscopy and laparoscopy, demonstrated a reduction of 1.8 days in the LOS when employing the MIO technique ($P < 0.001$). With the addition of the remaining 22 non-randomized studies, comprising 3 prospective and 19 retrospective cohort studies, which are heterogeneous with regard to their design, study populations and outcomes; data are available representing 3173 MIO and 25 691 OO procedures. In total, 13 studies (including the randomized trials) demonstrate a significant reduction in hospital LOS associated with MIO; 10 suggest no significant difference between techniques; and only 1 suggests a significantly greater length of stay associated with MIO. The only two randomized trials comparing MIO and OO demonstrated a reduction in length of stay in the MIO group, without compromising survival or increasing complication rates. All bar one of the non-randomized studies demonstrated either a significant reduction in length of stay with MIO or no difference. The benefit in reduced length of stay was not at the cost of worsened survival or increased complications, and conversion rates in all studies were low.

Keywords: Oesophagectomy • Minimally invasive • Open • Length of stay • Outcome

INTRODUCTION

A best evidence topic was constructed according to a structured protocol. This is fully described in the *ICVTS* [1].

THREE-PART QUESTION

In [patients undergoing oesophagectomy] does a [minimally invasive approach, compared to an open approach] convey benefit in [hospital length of stay]?

CLINICAL SCENARIO

A 65-year old male patient attends the outpatient department to discuss surgery for oesophageal cancer. You counsel him for open surgery, but he enquires about 'keyhole surgery', and thinks he would recover more quickly. You resolve to search the literature to provide an evidence-based answer.

SEARCH STRATEGY

A Medline® search from 1950 to November 2014 was performed, using the Ovid interface, with the following terms: 'Oesophag*.mp OR Esophag*.mp' AND 'minimally invasive.mp OR Thoracic Surgery, Video Assisted/ OR vats.mp OR video assisted.mp OR mio.mp OR mie.mp OR thoracoscop*.mp OR laparoscop*.mp' AND 'length of stay/ OR time to discharge.mp OR inpatient stay.mp OR patient stay.mp OR Patient Discharge/'.

SEARCH OUTCOMES

Six hundred and forty-seven papers were found using the search strategy. Where relevant, the full text versions of papers were

Table 1: Best evidence papers

Author (year), journal and country, Study type (level of evidence)	n_{OO}	n_{MIO}	Outcomes	OO result	MIO result	Sig. (*P*-value)	Comments
Biere *et al*. (2012), Lancet, Netherlands, Spain, Italy [2] Multicentre, open-label randomized controlled trial (level I)	56	59	Inpatient LOS (days) ITU LOS (days) Operative duration (min) Estimated blood loss (ml) Lymph node yield Mortality Reoperation Anastomotic leak Conversion	14 1 299 475 21 0 6 4 N/A	11 1 329 200 20 1 8 7 8	0.044 0.706 0.02 <0.001 0.852 NS 0.641 0.39 <0.001	Groups are comparable for all clinical and demographic factors at baseline. Eight conversions from MIO to OO were required OO: thoracotomy and laparotomy MIO: thoracoscopy and laparoscopy
Guo *et al*. (2013), Chin Ger J Clin Oncol, China [3] Open-label randomized controlled trial (level I)	111	111	Inpatient LOS (days) ITU LOS (days) Operative duration (min) Estimated blood loss (ml) Lymph node yield Mortality Reoperation Anastomotic leak	11.4 ± 2.3 3.2 ± 0.6 218.7 ± 91 590 ± 324.4 19.2 ± 12.5 0 NR 2	9.6 ± 1.7 3.3 ± 0.7 272.3 ± 57.9 219.7 ± 194.4 24.3 ± 21.0 0 NR 1	<0.001 0.256 <0.001 <0.001 <0.001 NS NR 0.556	Insufficient data presented regarding randomization. Prospective study. In-hospital mortality follow-up only was available. Little data presented regarding baseline characteristics of groups OO: transthoracic MIO: thoracoscopy and laparoscopy
Parameswaran *et al*. (2009), World J Surg, UK [4] Retrospective cohort study (level IIb)	30	50	Inpatient LOS (days) ITU LOS (days) Operative duration (min) Estimated blood loss (ml) Lymph node yield Mortality Reoperation Anastomotic leak Conversion	10 NR 266 NR 10 NR 5 1 0	12 NR 442 NR 23 NR 6 4 1	0.01 NR <0.01 NR <0.001 NR 0.75 NS NR	Patients operated on sequentially; OO 2002–2003; MIO 2004–2006. More females underwent OO, otherwise groups comparable for baseline characteristics OO: Ivor-Lewis MIO: thoracoscopy and laparoscopy
Pham *et al*. (2010), Am J Surg, USA [5] Retrospective cohort study (level IIb)	46	44	Inpatient LOS (days) ITU LOS (days) Operative duration (min) Estimated blood loss (ml) Lymph node yield Mortality Reoperation Anastomotic leak	14 4 437 780 8 2 NR 4	15 5 543 407 13 3 NR 5	0.51 0.35 <0.01 <0.01 <0.01 0.34 NR 0.78	Groups comparable for age, ASA, BMI and stage of malignancy. A higher proportion of women underwent OO. OO: Ivor-Lewis MIO: thoracoscopy and laparoscopy
Gao *et al*. (2011), Interact CardioVasc Thorac Surg, China [6] Retrospective cohort study (level IIb)	78	96	Inpatient LOS (days) ITU LOS (h) Operative duration (min) Estimated blood loss (ml) Lymph node yield Mortality Reoperation Anastomotic leak	17.5 ± 6.4 20.0 ± 4.2 284.3 ± 31.1 519.3 ± 47.7 28 ± 6.2 3 NR 6	12.6 ± 8.8 19.2 ± 3.5 330.2 ± 36.7 346.7 ± 41.1 27.8 ± 5.6 2 NR 7	<0.01 NS <0.01 <0.01 NS NS NR NS	Mortality follow-up was available at 30 days. No conversions from MIO to OO. Groups comparable in all demographic, clinical and pathological characteristics OO: McKeown MIO: three-field MIO with thoracotomy and laparoscopy
Schoppmann *et al*. (2010), Surg Endosc Austria [7]	31	31	Inpatient LOS (days) ITU LOS (days) Operative duration (min)	29 10 400	15 3 411	0.001 0.001 NS	Groups comparable in all demographic, clinical and pathological characteristics

Continued

Table 1: (*Continued*)

Author (year), journal and country, Study type (level of evidence)	n_{OO}	n_{MIO}	Outcomes	OO result	MIO result	Sig. (*P*-value)	Comments
Retrospective cohort study (level IIb)			Estimated blood loss (transfusion units) Lymph node yield Mortality Reoperation Anastomotic leak	0.9 ± 1.9 20.5 ± 12.6 6 10 8	0.52 ± 1.86 17.9 ± 7.7 1 4 1	0.014 NS 0.04 0.006 0.024	OO: thoracotomy and midline laparotomy MIO: thoracostomy and laparoscopy
Sihag *et al*. (2012), Eur J Cardiothorac Surg, USA [8] Retrospective cohort study (level IIb)	76	38	Inpatient LOS (days) ITU LOS (days) Operative duration (min) Estimated blood loss (ml) Lymph node yield Mortality Reoperation Anastomotic leak Conversion	9 ± 4 1 ± 1 365.5 ± 124 250 ± 200 21 ± 9 2 NR 0 N/A	7 ± 1 1 ± 0 360.5 ± 73 200 ± 100 19 ± 13 0 NR 2 2	<0.001 0.001 0.542 <0.001 0.74 0.552 NR 0.552	Groups comparable for age, sex, tumour histology, clinical stage, preoperative comorbidities and neoadjuvant therapy OO: Ivor-Lewis MIO: thoracoscopy/ laparoscopy
Kinjo *et al*. (2012), Surg Endosc, Japan [9] Prospective cohort study (level Ib)	79	72	Inpatient LOS (days) ITU LOS (days) Operative duration (min) Estimated blood loss (ml) Lymph node yield Mortality Reoperation Anastomotic leak Conversion	53 1 ± 7 268 ± 80 680 18 0 3 3 N/A	23 1 ± 2 308 ± 73 320 28 0 5 4 3	<0.001 0.114 <0.001 <0.001 0.002 NS 0.344 NS NR	Also evaluated hybrid MIO (thoracoscopic/ laparotomy-based) approach (data not included). Duration of thoracic procedure only is available OO: transthoracic MIO: thoracoscopy and laparoscopy
Sundaram *et al*. (2012), Surg Endosc, USA [10] Retrospective cohort study (level IIb)	26	47	Inpatient LOS (days) ITU LOS (days) Operative duration (min) Estimated blood loss (ml) Lymph node yield Mortality Reoperation Anastomotic leak Conversion	14 ± 10 5 ± 3 480 ± 180 700 ± 550 19 ± 10 0 NR 4 N/A	16 ± 10 4 ± 3 420 ± 190 0 ± 350 20 ± 13 2 NR 4 7	0.480 0.101 <0.001 <0.001 NS 0.577 NR 0.183 NR	Evaluated both open transthoracic and transhiatal approaches (data presented for former approach only). Groups comparable for sex and other variables; patients undergoing MIO were older by 2 years OO: thoracotomy and laparotomy MIO: modified Ivor-Lewis; thoracoscopy and laparoscopy with intrathoracic anastomosis
Ben-David *et al*. (2012), Surg Endosc, USA [11] Retrospective cohort study (level IIb)	32	100	Inpatient LOS (days) ITU LOS (days) Operative duration (min) Estimated blood loss (ml) Lymph node yield Mortality Reoperation Anastomotic leak	14 NR NR NR NR 2 NR 4	7.5 NR 330 ± 210 125 ± 200 NR 1 NR 4	0.05 NR NR NR NR 0.04 NR 0.04	Different surgical modalities performed at different centres. No group-specific, baseline demographic or clinical data presented. No data on conversions presented OO: thoracotomy and laparotomy MIO: thoracoscopy and laparoscopy, or Ivor-Lewis
Dolan *et al*. (2013), Surg Endosc, USA [12] Retrospective cohort study (level IIb)	64	71	Inpatient LOS (days) ITU LOS (days) Operative duration (min) Estimated blood loss (ml) Lymph node yield Mortality Reoperation Anastomotic leak Conversion	13.5 ± 16.2 3 ± 5 579 ± 98 500 ± 575 9.5 ± 10.2 3 NR 10 N/A	12.0 ± 8.0 3 ± 4 554 ± 112 250 ± 150 18 ± 9.8 2 NR 8 7	0.024 0.688 0.263 <0.001 <0.001 0.459 NR 0.285 NR	Groups comparable for age, sex and stage of malignancy; more MIO patients received chemo-/ radiotherapy. One conversion from MIO to OO was required OO: Ivor-Lewis with minor modifications

Continued

Table 1: (*Continued*)

Author (year), journal and country, Study type (level of evidence)	n_{OO}	n_{MIO}	Outcomes	OO result	MIO result	Sig. (*P*-value)	Comments
							MIO: three-field; with thoracoscopy and laparoscopy
Noble *et al*. (2013), Dis Esophagus, UK [13] Prospective cohort study (level Ib)	53	53	Inpatient LOS (days) ITU LOS (days) Operative duration (min) Estimated blood loss (ml) Lymph node yield Mortality Reoperation Anastomotic leak Conversion	12 1 240 400 19 24 5 2 N/A	12 1 300 300 18 15 6 5 4	0.358 0.995 0.0001 0.021 0.584 NS 0.75 NS NR	Groups comparable for age, gender, ASA, BMI, stage of malignancy and use of neoadjuvant therapy. Four conversions from MIO to OO were required. Mortality follow-up to a median of 17 months OO: Ivor-Lewis MIO: thoracoscopy and laparoscopy
Meng *et al*. (2014), J Thorac Dis, China [14] Retrospective cohort study (level IIb)	89	94	Inpatient LOS (days) ITU LOS (days) Operative duration (min) Estimated blood loss (ml) Lymph node yield Mortality Reoperation Anastomotic leak	17.1 ± 10.2 13 ± 14.6 247.8 ± 44.1 261.4 ± 87.2 17.4 ± 3.4 4 3 7	13.9 ± 7.5 9 ± 9.6 251.3 ± 45.4 182.6 ± 78.3 16.2 ± 3.1 1 2 6	0.017 0.295 0.617 <0.001 0.132 0.155 0.951 0.696	Groups comparable for demographic and pathological characteristics OO: three-field; thoracotomy and laparotomy MIO: thoracoscopy and laparoscopy
Fabian *et al*. (2008), Dis Esophagus, USA [15] Retrospective cohort study (level IIb)	43	22	% discharged within 10 days Inpatient LOS (days) ITU LOS (days) Operative duration (min) Estimated blood loss (ml) Lymph node yield Mortality Reoperation Anastomotic leak	12 11 NR 270 ± 87 356 ± 136 8 ± 7 4 NR 3	16 9.5 NR 333 ± 72 178 ± 96 15 ± 6 1 NR 3	0.006 0.30 NR 0.01 <0.0001 0.0002 0.45 NR NS	Groups comparable for age, sex, diagnosis, stage of malignancy and use of neoadjuvant therapy. One conversion of MIO to OO was required OO: various ('surgeon preference') MIO: thoracoscopy and/or laparoscopy
Lazzarino *et al*. (2010), Ann Surg, UK [16] Retrospective cohort study (level IIb) (National-level data used)	17 974	699	Inpatient LOS (days) ITU LOS (days) Operative duration (min) Estimated blood loss (ml) Lymph node yield Mortality Reoperation Anastomotic leak	16 NR NR NR NR 566 NR NR	15 NR NR NR NR 9 NR NR	0.96 NR NR NR NR 0.55 NR NR	Not comparable for socioeconomic status or comorbidity MIO: thoracoscopy or laparoscopy OO: any other procedure
Mamidanna *et al*. (2012), Ann Surg, UK [17] Retrospective cohort study (level IIb) (National-level data used)	6347	1155	Inpatient LOS (days) ITU LOS (days) Operative duration (min) Estimated blood loss (ml) Lymph node yield Mortality Reoperation Anastomotic leak	15 NR NR NR NR 274 355 NR	15 NR NR NR NR 46 102 NR	<0.001 NR NR NR NR 0.605 <0.001 NR	Non-malignant underlying causes excluded. Groups comparable for demographic variables apart from socioeconomic deprivation MIO: any use of thoracoscopy or laparoscopy. If both used, classed as 'total MIE'. OO: any other procedure
Bakhos *et al*. (2012), Ann Thorac Surg, USA [18]	121	99	Inpatient LOS (days) ITU LOS (days) Operative duration (min) Estimated blood loss (ml)	11 ± 19.5 NR NR NR	10 ± 8.8 NR NR NR	0.06 NR NR NR	Groups comparable for age, sex and receipt of neoadjuvant therapy. Six conversions from MIO to

Continued

BEST EVIDENCE TOPIC

Table 1: (*Continued*)

Author (year), journal and country, Study type (level of evidence)	n_{OO}	n_{MIO}	Outcomes	OO result	MIO result	Sig. (*P*-value)	Comments
Retrospective cohort study (level IIb)			Lymph node yield	NR	NR	NR	OO were required. Focus of study was on pulmonary morbidity after oesophagectomy
			Mortality	5	3	0.73	
			Reoperation	NR	NR	NR	
			Anastomotic leak	15	9	0.52	
			Conversion	N/A	6	NR	OO: various: Ivor-Lewis, McKeown, transhiatal and left thoracic/ thoracoabdominal MIO: thoracoscopy and laparoscopy
Dhamija *et al.* (2014), Eur J Cardiothorac Surg, USA [19]	64	61	Inpatient LOS (days)	9	8	NS	Evaluated both open transthoracic and transhiatal approaches (data presented for latter approach only). Study focused on economic costs of OO versus MIO
			ITU LOS (days)	2	3	NS	
			Operative duration (min)	NR	NR	NR	
			Estimated blood loss (ml)	NR	NR	NR	
Retrospective cohort study (level IIb)			Lymph node yield	NR	NR	NR	
			Mortality	2	2	NS	
			Reoperation	NR	NR	NR	
			Anastomotic leak	NR	NR	NR	
			Conversion	N/A	1	NR	OO: Ivor-Lewis, modified McKeown and thoracoabdominal approaches MIO: thoracoscopy and laparoscopy
Cash *et al.* (2014), Surg Endosc, USA [20]	33	60	Inpatient LOS (days)	13	10	<0.0001	Groups poorly comparable for age, sex, comorbidities and cancer stage. Two conversions from MIO to OO were required
			ITU LOS (days)	NR	NR	NR	
			Operative duration (min)	274	275.5	NS	
			Estimated blood loss (ml)	NR	NR	NR	
Retrospective cohort study (level IIb)			Lymph node yield	NR	NR	NR	
			Mortality	1	0	0.39	
			Reoperation	6	0	0.56	OO: transhiatal MIO: laparoscopic transhiatal
			Anastomotic leak	8	3	0.72	
			Conversion	NR	2	NR	
Hamouda *et al.* (2010), Surg Endosc, UK [21]	24	26	Inpatient LOS (days)	14	16	NS	Evaluated open Ivor-Lewis oesophagectomy versus laparoscopic Ivor-Lewis procedure in both early and late cohorts. Data from the late cohort are presented
			ITU LOS (days)	3	4	NS	
			Operative duration (min)	260	223	NS	
Prospective cohort study (level Ib)			Estimated blood loss (transfusion units)	4.5	4	NS	
			Lymph node yield	24	23	NS	
			Mortality	0	0	NS	
			Reoperation	1	4	NS	
			Anastomotic leak	2	4	NS	OO: Ivor-Lewis MIO: laparoscopic Ivor-Lewis
Berger *et al.* (2011), J Am Coll Surg, USA [22]	53	65	Inpatient LOS (days)	16	9	0.003	Groups comparable for demographic data. A few patients in the MIO group (15%) underwent thoracoscopy with laparotomy
			ITU LOS (days)	NR	NR	NR	
			Operative duration (min)	NR	NR	NR	
			Estimated blood loss (ml)	619	182	<0.0001	
Retrospective cohort study (level IIb)			Lymph node yield	9	20	<0.0001	
			Mortality	4	5	1.0	
			Reoperation	NR	NR	NR	
			Anastomotic leak	6	9	1.0	OO: thoracotomy, either by Ivor-Lewis or three-hole MIO: thoracoscopy and laparoscopy
Smithers *et al.* (2007), Ann Surg, USA [23]	114	23	Inpatient LOS (days)	14	11	0.03	Also evaluated a hybrid MIO (thoracoscopic/ laparotomy-based) approach (data not
			ITU LOS (h)	23	19	0.03	
			Operative duration (min)	300	330	0.01	
Retrospective cohort			Estimated blood loss (ml)	600	300	0.017	

Continued

Table 1: (*Continued*)

Author (year), journal and country, Study type (level of evidence)	n_{OO}	n_{MIO}	Outcomes	OO result	MIO result	Sig. (*P*-value)	Comments
study (level IIb)			Lymph node yield Mortality Reoperation Anastomotic leak Conversion	16 3 NR 10 NR	17 0 NR 1 12	NS NS NR NS NR	included). Significant intergroup differences in demographic and clinical variables. Two conversions of MIO to OO OO: open thoracotomy and laparotomy. MIO: total thoracoscopic and laparoscopic approach
Zingg *et al*. (2009), Ann Thorac Surg, Austria [24] Retrospective cohort study (level IIb)	98	56	Inpatient LOS (days) ITU LOS (days) Operative duration (min) Estimated blood loss (ml) Lymph node yield Mortality Reoperation Anastomotic leak Conversion	21.9 6.8 209.4 857 6.7 6 9 11 NR	19.7 3.0 250.2 320 5.7 2 5 11 5	0.463 0.022 <0.001 <0.001 0.144 0.467 NS 0.341 NR	To minimize selection bias, only patients who met the selection criteria for the MIO approach were included in the OO group OO: primarily Ivor-Lewis MIO: thoracoscopy and laparoscopy
Blom *et al*. (2012), J Thorac Dis, Netherlands [25] Retrospective cohort study (level IIb)	49	41	Inpatient LOS (days) ITU LOS (days) Operative duration (h) Estimated blood loss (ml) Lymph node yield Mortality Reoperation Anastomotic leak Conversion	13 1 5.2 500 25 0 NR 1 NR	11 1 6 100 19 1 NR 4 2	0.072 0.188 <0.001 <0.001 <0.001 0.456 NR 0.173 NR	Groups comparable for baseline characteristics. Two patients required conversion from MIO to OO. In-hospital mortality follow-up only was available OO: thoracotomy and laparotomy MIO: thoracoscopy and laparoscopy

All values presented are median ± interquartile range, unless otherwise specified.
ASA: American Society of Anesthesiologists classification; BMI: body mass index; ITU: intensive treatment unit; LOS: length of stay; MIO: minimally invasive oesophagectomy; ml: millilitres; NR: not reported; NS: not significant; OO: open oesophagectomy; U: units.

retrieved, and reference lists cross-checked. Studies with the level of evidence I and II (e.g. randomized controlled trials, meta-analyses or well-designed, controlled, observational studies) with ≥50 participants were included. This process yielded 24 papers, which were deemed to offer the best evidence. The key data from these papers are detailed in Table 1.

RESULTS

Of the 24 studies identified, data from two randomized controlled trials were available. Biere *et al.* [2] randomized 115 patients to undergo either open oesophagectomy (OO; thoracotomy and laparotomy, $n = 56$) or minimally invasive oesophagectomy (MIO; thoracoscopy and laparoscopy, $n = 59$). An open-label, multicentre design, with randomization via computer-generated sequence, and rigorous intention-to-treat analysis, was employed. The authors report that those who underwent MIO left hospital on average 3 days earlier than those treated with the open technique (11 vs 14 days, respectively; $P = 0.044$). A further randomized controlled trial, by Guo *et al.* [3], enrolled 221 patients, who were similarly randomized in a single-blind, 1 : 1 fashion, to receive either thoracotomy with thoracoscopy ($n = 111$) or laparoscopy ($n = 111$). The authors observed an average reduction of 1.8 days in the LOS in patients managed by the MIO strategy, as opposed to an OO approach (9.6 vs 11.4 days, respectively; $P < 0.001$). Both studies demonstrated no differences in mortality or the overall complication rate; however, in the study by Guo *et al.*, there was a trend towards fewer pulmonary infections in the MIO group ($n = 3$) compared with the OO group ($n = 9$, $P = 0.072$) [3].

Within the remaining 22 non-randomized studies, data for a total of 3003 minimally invasive and 25 524 open oesophagectomies were available, in the form of 3 prospective and 19 retrospective cohort studies.

Eleven studies compared thoracotomy and laparotomy with thoracoscopy and laparoscopy [4–14], with 8 noting a significant reduction in hospital LOS in the MIO group, and 2 noting no difference [5–14]. The study by Parameswaran *et al.* [4] demonstrated a statistically longer MIO LOS (12 days) compared with the OO LOS (10 days, $P = 0.01$). The authors explain that the technique was new to their unit (which covered a large geographic patient catchment area) and they wished to retain patients to ensure there were no late complications with the technique. In those non-randomized studies where demographic data were available, groups were generally comparable in age, American Society of Anesthesiologists classification and stage of malignancy.

A further study, by Fabian *et al.* [15], compared their surgeons' own preferred open method with a thoracoscopic procedure with or without laparoscopic assistance, observing a non-significant reduction of 1.5 days spent in hospital within the MIO group ($P = 0.3$).

Four groups compared the use of any open procedure with laparoscopy and/or thoracoscopy, analysing data for over 26 000 patients [16–19]. However, only one of these studies showed a statistically significant reduction in hospital length of stay (LOS) [17].

A further study compared the use of laparotomy with laparoscopy, noting a significant reduction in LOS of 3 days in the MIO group ($P < 0.0001$) [20]. This was a non-randomized study [20] with patients undergoing MIO being older and with significantly more comorbidities. However, these factors would be expected to lengthen, rather than shorten, LOS, and as such the significance of the MIO approach may have been underestimated.

Three studies compared the use of hybrid procedures with both thoracotomy and laparotomy, and thoracoscopy and laparoscopy. Hamouda *et al.* [21] compared OO and MIO procedures with a hybrid procedure consisting of a thoracotomy with laparoscopic assistance, finding a non-significant increase in the LOS of 2 days in the MIO group. Those treated with the hybrid procedure also required an intensive care unit stay 1 day longer than those in the open group, though this was non-significant, and the authors did not pass any comment on the potential reasons for the difference. Berger *et al.* [22] compared OO and MIO techniques while performing an additional small number of hybrid procedures consisting of thoracoscopically assisted laparotomy, which they grouped with the MIO cohort. They observed that the use of MIO led to a 7-day shorter hospital stay ($P = 0.003$). Smithers *et al.* [23] also compared the use of thoracoscopic-assisted laparotomy with OO and MIO techniques, noting reductions in stay of 3 and 1 day(s) with the MIO and hybrid techniques, respectively ($P = 0.03$).

The remaining two studies chose to compare the use of thoracotomy alone with a combined thoracoscopic and laparoscopic approach. There were no significant differences in LOS observed in either study [24, 25].

Of the 22 non-randomized studies, 6 studies noted a significant reduction in the complication rate using the MIO technique, while only 1 noted an increase, with the remaining 15 noting no difference. One study noted a significant reduction in the 30-day mortality using the MIO technique, while the remaining 21 noted no difference.

Importantly, for those 1011 patients whose data were available, conversion from an MIO to an open technique was required in 7.5% of cases.

CLINICAL BOTTOM LINE

The only two randomized trials comparing MIO and OO demonstrated a reduction in the LOS in the MIO group, without compromising survival or increasing complication rates. All except one of the non-randomized studies demonstrated either a significant reduction in LOS with MIO or no difference. The benefit in reduced LOS was not at the cost of worsened survival or increased complications.

Conflict of interest: none declared.

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