Total or Hybrid Minimally Invasive Esophagectomy?

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8.1 Introduction

Oesophageal cancer's global incidence continues to increase rapidly. In Western society this is reflected by an increasing incidence of oesophageal adenocarcinomas, with the epidemiological shift felt to be related to increased obesity, gastro-oesophageal reflux disease, and Barrett's oesophagus—the dominant risk factors for the development of this tumour. Surgical resection with radical lymphadenectomy, usually after the administration of neoadjuvant chemotherapy or chemoradiotherapy, remains the key component in the multimodality treatment of oesophageal cancer. Oesophagectomy is a complex surgical procedure for which the mortality rates have historically been significant [1]. In the modern practice of high volume centres with appropriate multidisciplinary teams, the mortality rate after oesophageal resection has been reduced significantly [2]. Despite this boon, it remains an operation associated with substantial rates of morbidity. Hence, minimally invasive surgery has been championed in the previous three decades as a means of reducing postoperative morbidity for a variety of oncological gastrointestinal resections. Concerning oesophageal resection, it has been hoped that the application of minimally invasive surgery may similarly reduce postoperative morbidity and mortality. By the early 1990s, some surgeons had developed and used protocols for thoracoscopic oesophagectomy, initially restricting its use to T1 and T2 oesophageal cancer without neoadjuvant chemoradiation [3, 4]. Subsequently, indications for minimally invasive oesophagectomy (MIO) have been expanded to include more advanced disease, irrespective of the whether patients have received neoadjuvant treatments.

The techniques representing minimally invasive approaches to oesophageal resection vary widely. Many authors have described totally minimally invasive approaches (thoracoscopy and laparoscopy) whilst others describe hybrid procedures where one stage of the operation is performed either by thoracoscopy or laparoscopy and the other by conventional open surgery.

Why, unlike other minimally invasive procedures, has MIO not been broadly adopted? Regardless what approach is used, MIO remains a very complex operation with many questions remaining unanswered as to the real advantages of applying a minimally invasive technique for resection of a disease that often is advanced at the time of surgery. Whereas the feasibility and safety

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of MIO have been assessed in a prospective phase II multicenter study [5], yet the mortality, morbidity, oncological radicality, reproducibility and the cost of the procedure remain topics under debate for implementing MIO. Many retrospective and comparative non-randomized studies, as included in some recent meta-analyses focusing on the role of MIO [6–10], have been conducted. Given only two randomized trials have been reported to date, uncertainty remains about the advantages of MIO compared to open oesophagectomy.

In the absence of meta-analyses of randomized controlled studies, this chapter appraises the available literature regarding the short-term perioperative and long-term oncological outcomes for patients undergoing MIO for cancer, with a focus on the total versus hybrid approaches.

8.2 MIO Techniques

As there has never been a consensus regarding the superiority of any of the various open oesophagectomy techniques, it comes as no surprise that agreeing on what constitutes the best minimally invasive approach is difficult.

Totally minimally invasive approaches to oesophageal resection attempt to replicate established open procedures. A minimally invasive transhiatal technique utilizes laparoscopic abdominal dissection and preparation of the gastric conduit followed by a cervical anastomosis created via a traditional open approach in the neck. Mediastinal dissection of perioesophageal lymph nodes, including those in the subcarinal station, can be assessed through the hiatus using the lighting and magnification afforded by the laparoscopic camera. The oesophageal specimen can be removed through the neck incision. Some surgeons prefer to combine the laparoscopic transhiatal approach with a mini-laparotomy to facilitate gastric tube creation as well as to remove the specimen. Finally, the oesophagus can also be removed from the mediastinum via an inversion technique with or without division of the vagus nerve. As with open surgery, many surgeons prefer a thoracoscopic approach, typically performed through the right chest, with patients positioned in lateral decubitus or prone positions. Thoracoscopy can be used as a part of a three-stage MIO, where the procedure begins in the chest and ends with laparoscopy and a cervical anastomosis, or as part of the two-stage Ivor Lewis oesophagectomy where the oesophagogastric anastomosis resides in the chest. In this procedure, the specimen is removed through a mini-thoracotomy, and the anastomosis is created at the apex of the chest.

Combinations of open and minimally invasive techniques (hybrid techniques) are perhaps more widely utilized, such as laparoscopy with thoracotomy or thoracoscopy with laparotomy. These hybrid techniques are applied for a variety of reasons and may be necessitated by oncological considerations, prior surgery in either cavity, surgeon experience and surgeon preference.

Although the goal of MIO is to perform an equivalent operation to the open procedure without omitting any critical steps, some aspects considered as routine for open oesophagectomy have fallen out of favour with many surgeons, such as performance of a pyloroplasty and jejunostomy placement.

8.3 MIO Postoperative Outcomes

The primary goal of MIO is to decrease surgical morbidity associated with the open approach. Except sparse data coming from randomized controlled trials to be further detailed [11–13], most data derives from retrospective or prospective non-randomized series. These suggest that mortality rates appear equivalent or even lower in large comparative cohorts, with some evidence of a reduced postoperative complication rate favouring the minimally invasive approach (Tables 8.1 and 8.2). It is likely that the benefits of MIO may be overshadowed by the persistent rate of significant morbidity, which continues to occur independent of surgical approach. It seems conceivable that in the absence of such complications, patients with a minimal-access approach enjoy quicker recovery, a quicker return to normal activities and decreased long-term pain when compared to patients with similarly uncomplicated open procedures. This, however, has yet to be proven.

Table 8.1 Mortality and overall morbidity of minimally invasive and open oesophagectomy

Authors	n	Approaches	Mortality n (%)	Overall morbidity n (%)
Law et al. [14]	22	MIO (TSO)	0	18 (81.8)
	63	Open	0	63 (100)
Nguyen et al. [15]	18	MIO (TLSO)	0	7 (38.9)
	36	Open	0	19 (52.8)
Osugi et al. [16]	77	MIO (VATS)	0	31 (40.3)
	72	Open	0	32 (44.4)
Kunisaki et al. [17]	15	MIO (VATS + HALS)	0	NS
	30	Open	0	NS
Van den Broek et al. [18]	25	MIO (THO)	0	14 (70)
	20	Open	0	18 (72)
Bresadola et al. [19]	14	MIO (THO and TLSO)	0	8 (57.1)
	14	Open	0	6 (42.9)
Bernabe et al. [20]	17	MIO (THO)	0	NS
	14	Open	0	NS
Shiraishi et al. [21]	116	MIO (TLSO)	3 (2.6)	NS
	37	Open	3 (8.1)	NS
Braghetto et al. [22]	47	MIO (VATS/LSO)	3 (6.3)	18 (38.2)
	119	Open	13 (10.9)	72 (60.5)
Smithers et al. [23]	332	MIO (TLSO)	7 (2.1)	207 (62.3)
	114	Open	3 (2.6)	76 (66.7)
Fabian et al. [24]	22	MIO (TLSE)	1 (4.5)	15 (68.2)
	43	Open	4 (9.8)	31 (72.1)
Zingg et al. [25]	56	MIO (TLSO)	2 (3.6)	19 (34.5)
	98	Open	6 (6.1)	20 (23.5)
Perry et al. [26]	21	MIO (LIO)	0	13 (62)
	21	Open	1 (5)	17 (81)
Parameswaran et al. [27]	50	MIO (TLSO)	1 (2)	24 (48)
	30	Open	1 (3)	15 (50)
Pham et al. [28]	44	MIO (TLSO)	3 (6.8)	NS
	46	Open	2 (4.3)	NS
Schoppman et al. [29]	31	MIO (TLSO)	0	11 (35.5)
	31	Open	0	23 (74.2)
Singh et al. [30]	33	MIO (TLSO)	Values NS	Values NS
	31	Open	p = 0.34	P = 0.06
Mamidanna et al. [31]	1155	MIO (TLSO, HMIO)	46 (4.0)	NS
	6347	Open	274 (4.3)	NS
Ben-David et al. [32]	100	MIO (TLSO)	1 (1)	NS
	32	Open	2 (5)	NS
Briez et al. [33]	140	MIO (HMIO)	2.1	35.7
	140	Open	12.9	59.3
Xie et al. [34]	106	MIO (TLSO)	2 (1.9)	28 (26.4)
	163	Open	4 (2.5)	56 (34.4)
Hsu et al. [35]	66	MIO (TLSO)	5 (7.6)	NS
	63	Open	5 (7.9)	NS

MIO minimally invasive oesophagectomy, *VATS* video-assisted thoracoscopic oesophagectomy, *HMIO* hybrid MIO, *HALS* hand-assited laparoscopic oesophagectomy, *TSO* thoracoscopic-assisted oesophagectomy, *TLSO* thoracolaparoscopic oesophagectomy, *LIO* laparoscopic inversion oesophagectomy, *LSO* laparoscopic oesophagectomy, *NS* not stated

Table 8.2 Comparison of rates of morbidities for MIO and open oesophagectomy

Authors	n	Approaches	Pneumonia n (%)	Cardiac arrhythmia n (%)	Anastomotic leak n (%)	Gastric conduit ischemia n (%)	Chylothorax n (%)	Length of stay (days)	Operative blood loss (mls)	Operative time (min)
Law et al. [14]	22	MIO (TSO)	3 (13.6)	3 (13.6)	0	NS	NS	NS	450 (200–800)	240 (160–350)
	63	Open	11 (17.5)	14 (22.2)	2 (3.2)	NS	NS	NS	700 (300–2500)	250 (190–420)
Nguyen et al. [15]	18	MIO (TLSO)	2 (11.1)	NS	2 (11.1)	0	0	11.3±14.2	297±233	364±73
	36	Open	6 (16.7)	NS	4 (11.1)	1 (2.8)	1 (2.8)	22.8±18.0	1108±790	411±93
Osugi et al. [16]	77	MIO (VATS)	12 (15.6)	1 (1.3)	1 (1.3)	0	3 (3.9)	NS	284 (330)	227 (90)
	72	Open	14 (19.4)	3 (4.2)	2 (2.8)	0	0	NS	310 (170)	186 (35)
Kunisaki et al. [17]	15	MIO (VATS + HALS)	0	NS	2 (13.3)	NS	NS	29.6±12.9	447.9 (±214.8)	544.4 (±64.5)
	30	Open	1 (3.3)	NS	1 (3.3)	NS	NS	32.7±14.0	674.7 (±445.6)	487.8 (±97.8)
Van den Broek et al. [18]	25	MIO (THO)	2 (8)	NS	2 (8)	0	2 (8)	16	NS	NS
	20	Open	2 (10)	NS	3 (15)	0	0	16	NS	NS
Bresadola et al. [19]	14	MIO (THO and TLSO)	1 (7.1)	NS	1 (7.1)	NS	0	16.4 (±8.4)	NS	469.0 (±42.6)
	14	Open	2 (14.2)	NS	2 (14.2)	NS	0	22.3 (±10.6)	NS	370.8 (±16.7)
Bernabe et al. [20]	17	MIO (THO)	NS	NS	NS	NS	NS	9.1 (±3.2)	331 (±220)	336 (±53)
	14	Open	NS	NS	NS	NS	NS	11.6 (±2.9)	542 (±212)	388 (±102)
Shiraishi et al. [21]	116	MIO (TLSO)	25 (21.6)	3 (2.6)	13 (11.2)	NS	NS	NS	670.2 (±561.1)	426.0 (±87.1)
	37	Open	12 (32.4)	4 (10.8)	9 (24.3)	NS	NS	NS	487.4 (±110.5)	487.4 (±110.5)
Braghetto et al. [22]	47	MIO (VATS/ LSO)	7 (14.8)	NS	3 (6.4)	0	1 (2.1)	NS	NS	NS
	119	Open	22 (18.5)	NS	17 (14.3)	1 (0.8)	0	NS	NS	NS
Smithers et al. [23]	332	MIO (TLSO)	87 (26.2)	55 (16.6)	18 (5.4)	5 (1.5)	17 (5.1)	11 (7–49)	300 (15–1000)	330 (270–540)
	114	Open	35 (27.8)	21 (18.4)	10 (8.7)	2 (1.7)	7 (6.1)	14 (8–44)	600 (0–3000)	300 (150–480)
Fabian et al. [24]	22	MIO (TLSE)	1 (4.5)	4 (18.2)	3 (13.6)	1 (4.5)	0	9.5	178 (±96)	333 (±72)
	43	Open	10 (23.3)	8 (18.6)	3 (7.0)	0	2 (4.7)	11	356 (±136)	270 (±87)
Zingg et al. [25]	56	MIO (TLSO)	17 (30.9)	NS	NS	NS	NS	19.7 (±2.0)	320 (±49)	250 (±7.2)
	98	Open	33 (38.8)	NS	NS	NS	NS	21.9 (±2.0)	857 (±82)	209 (±7.8)
Perry et al. [26]	21	MIO (LIO)	1 (5)	4 (19)	4 (19)	NS	NS	10 (8–14)	168 (149)	399 (86)
	21	Open	2 (10)	7 (33)	6 (29)	NS	NS	14 (10–19)	526 (289)	408 (127)

Table 8.2 (continued)

Authors	n	Approaches	Pneumonia n (%)	Cardiac arrhythmia n (%)	Anastomotic leak n (%)	Gastric conduit ischemia n (%)	Chylothorax n (%)	Length of stay (days)	Operative blood loss (mls)	Operative time (min)
Parame-swaran et al. [27]	50	MIO (TLSO)	4 (8)	NS	4 (8)	5 (16)	3 (6)	12 (8–86)	NS	442 (305–580)
	30	Open	2 (7)	NS	1 (3)	2 (10)	1 (3)	10 (6–56)	NS	266 (219–390)
Pham et al. [28]	44	MIO (TLSO)	11 (25)	NS	4 (9)	1 (2)	NS	15 (12–20)	407 (±267)	543 (72.6)
	46	Open	7 (15)	NS	5 (11)	1 (2)	NS	14 (11–23)	780 (± 610)	437 (97.0)
Schoppman et al. [29]	31	MIO (TLSO)	2 (6.2)	NS	1 (3.2)	0	2 (6.4)	NS	NS	411 (270–600)
	31	Open	11 (35.5)	NS	8 (25.8)	1 (3.2)	1 (3.2)	NS	NS	400 (240–550)
Singh et al. [30]	33	MIO (TLSO)	NS	NS	NS	NS	NS	No difference	Reduced after MIO	Longer for MIO
	31	Open	NS	NS	NS	NS	NS	($p = 0.17$)	($p < 0.01$)	($p < 0.01$)
Mamidanna et al. [31]	1155	MIO (TLSO, HMIO)	230 (19.9)	102 (8.8)	NS	NS	NS	15 (12–23)	NS	NS
	6347	Open	1181 (18.6)	611 (9.6)	NS	NS	NS	15 (12–22)	NS	NS
Ben-David et al. [32]	100	MIO (TLSO)	9 (9)	8 (8)	5 (5)	NS	3 (3)	7.5 (6–49)	125 (100–300)	330 (270–480)
	32	Open	5 (15.6)	NS	4 (12.5)	NS	NS	14 (10–98)	NS	NS
Briez et al. [33]	140	MIO (HMIO)	15.7	NS	5.7	0.7	NS	12 (8–80)	NS	NS
	140	Open	42.9	NS	4.3	0.0	NS	16 (8–180)	NS	NS
Xie et al. [34]	106	MIO (TLSO)	2 (1.9)	NS	5 (4.7)	NS	4 (3.8)	11.8 (±6.7)	187.2 (±37.8)	249.6 (±41.7)
	163	Open	8 (4.9)	NS	6 (3.7)	NS	5 (3.1)	13.9 (±7.3)	198.5 (±46.5)	256.3 (±41.7)
Hsu et al. [35]	66	MIO (TLSO)	7 (10.6)	NS	18 (27.3)	NS	4 (6.1)	NS	462.4 (±467.8)	510.9 (±121.3)
	63	Open	16 (25.4)	NS	19 (30.2)	NS	3 (4.8)	NS	615.5 (±591.6)	460.5 (±92.4)

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Results coming from five published meta-analyses, based on non-randomized comparative data, are contradictory. Two did not find significant differences between the MIO and the open approaches [36, 37] whereas three suggest that patients undergoing MIO had better postoperative outcomes with no compromise in oncological outcomes [8–10]. Patients undergoing MIO had significantly lower blood loss, and shorter postoperative ICU and hospital stay. There was a 30–50% decrease in overall morbidity in the MIO group. Subgroup analyses demonstrated significantly lower incidence of medical related complications, especially respiratory complications after MIO. However, surgical related postoperative outcomes such as anastomotic leak, anastomotic stricture, gastric conduit ischemia, chyle leak, and vocal cord palsy were globally comparable between the two techniques. Regarding postoperative mortality, the largest meta-analysis having included 48 studies and 14,311 patients, identified a reduced incidence of intra-hospital postoperative mortality (OR 0.69, 95% CI 0.55–0.89) [10]. This has been confirmed by a large French study that exhibited a reduction of 30-day (5.9% vs. 3.3%, p = 0.029) and 90-day (10.1% vs. 6.9%, p = 0.018) postoperative mortality favouring the MIO approach [38].

8.4 MIO Oncological Outcomes

If MIO is to become the approach of choice, then it must demonstrate not to compromise oncological outcomes. Improved lighting and visibility, along with the magnification afforded by minimally invasive equipment, may prove superior for meticulous dissection and lymph node harvest. However, not until large series report long-term survival by stage and pending published results of large randomized trials, the true oncologic value of MIO will remain controversial. Table 8.3 reflects the fact that no study to date has shown conclusive evidence of improved overall survival favouring a minimally invasive resection. Whilst several studies have suggested a benefit in terms of lymph node harvest, yet many have failed to meet the broadly accepted recommendations of the number of lymph nodes that should be retrieved for optimum staging and prognosis (Table 8.3). This puts into some question the quality of resection in several studies and makes oncological comparisons difficult. In a meta-analysis comparing oncological outcomes of MIO versus open group, the median (range) number of lymph nodes found was higher in the MIO group (16 (5.7–33.9)) compared to the open group (10 (3.0–32.8), p = 0.04); whereas no statistical difference was found for survival within respective time interval, although the difference favoured the MIO group [9]. More data on oncological data outcomes is needed, especially from future randomized controlled trials.

Table 8.3 Long-term oncological outcomes for MIO and open oesophagectomy

Authors	N	Approaches	Number of lymph nodes retrieved (median)	RO resection rate n (%)	3-year survival
Law et al. [14]	22	MIO (TSO)	7 [2–13]	10	62% (2 years)
	63	Open	13 [5–34]	NS	63% (2 years)
Nguyen et al. [15]	18	MIO (TLSO)	10.8±8.4	18	NS
	36	Open	6.6±5.8	NS	NS
Osugi et al. [16]	77	MIO (VATS)	33.9±12	NS	70%
	72	Open	32.8±14	NS	60%
Kunisaki et al. [17]	15	MIO (VATS + HALS)	24.5±10	NS	NS
	30	Open	26.6±10.4	NS	NS
Van den Broek et al. [18]	25	MIO (THO)	7±4.9	21 (84)	60% (f/u 17±11 months)
	20	Open	6.5±4.9	18 (90)	50% (f/u 54±16 months)
Bresadola et al. [19]	14	MIO (THO/TLSO)	22.2±12	NS	NS
	14	Open	18.6±13.4	NS	NS
Bernabe et al. [20]	17	MIO (THO)	9.8 (NS)	NS	NS
	14	Open	8.7 (NS)	NS	NS
Shiraishi et al. [21]	116	MIO (TLSO)	31.8 (NS)	NS	NS
	37	Open	30.1 (NS)	NS	NS
Braghetto et al. [22]	47	MIO (VATS/LSO)	NS	NS	45.5%
	119	Open	NS	NS	32.5%
Smithers et al. [23]	332	MIO (TLSO)	17 [9–33]	263	42%
	114	Open	16 [1–44]	90	30%
Fabian et al. [24]	22	MIO (TLSE)	15±6	22 (100)	NS
	43	Open	8±7	NS	NS

Table 8.3 (continued)

Authors	N	Approaches	Number of lymph nodes retrieved (median)	RO resection rate n (%)	3-year survival
Zingg et al. [25]	56	MIO (TLSO)	5.7±0.4	NS	Median survival – 35 months MIO 29 months Open
	98	Open	6.7±0.5	NS	
Perry et al. [26]	21	MIO (LIO)	10 [4–12]	NS	NS
	21	Open	3 [0–7]	NS	NS
Parameswaran et al. [27]	50	MIO (TLSO)	23 [7–49]	NS	74% (2 year survival)
	30	Open	10 [2–23]	NS	58% (2 year survival)
Pham et al. [28]	44	MIO (TLSO)	13 [9–15]	NS	NS
	46	Open	8 [3–14]	NS	NS
Schoppman et al. [29]	31	MIO (TLSO)	17.9±7.7	29 (93.5)	64%
	31	Open	20.5±12.6	30 (96.8)	46%
Singh et al. [30]	33	MIO (TLSO)	14 (6–16)	30	55% (2 year survival)
	31	Open	8 (3–14)	30	32% (2 year survival)
Mamidanna et al. [31]	1155	MIO (TLSO/HMIO)	NS	NS	NS
	6347	Open	NS	NS	NS
Ben-David et al. [32]	100	MIO (TLSO)	NS	99 (99)	NS
	32	Open	NS	32 (100)	NS
Briez et al. [33]	140	MIO (HMIO)	22 [8–53]	85.7	58% (2 year survival)
	140	Open	22 [6–56]	87.9	57% (2 year survival)
Xie et al. [34]	106	MIO (TLSO)	30.4 (±5.4)	NS	NS
	163	Open	30.2 (±5.0)	NS	NS
Hsu et al. [35]	66	MIO (TLSO)	28.3 (±16.6)	64 (97.0)	70.9%
	63	Open	25.9 (±15.3)	61 (96.8)	47.6%

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8.5 Results from Two Randomized Controlled Trials

Up till now, results of two multicentre randomised controlled trials have been reported comparing the results of minimally invasive and open oesophagectomy [11–13]: the TIME trial and the MIRO trial.

The TIME trial randomly assigned 56 patients to open oesophagectomy and 59 to a minimally invasive operation with all patients receiving equivalent neoadjuvant chemotherapy or chemoradiotherapy regimes. Both minimally invasive and open surgical groups had a mixture of two-stage and three-stage operations with the majority of patients having a cervical anastomosis. The primary outcome measure chosen was pulmonary infection within 2 weeks of surgery defined by clinical manifestation of pneumonia confirmed by radiological imaging and a positive sputum sample. Sixteen patients (29%) in the open surgical group and five (9%) patients in the minimally invasive group ($p = 0.005$) developed pneumonia in the first two postoperative weeks. These results suggest a significant benefit in terms of respiratory complications in favour of the minimally invasive approach, even if some qualifications could be made [39]. Mid-term 1-year results were recently reported with a high rate of symptomatic anastomotic stenosis, which was similar between the MIO and the open group (44% vs. 39%), and a better quality of life in favor of MIO for the physical component summary of the SF 36 questionnaire, EORTC C30 global health domain and OES18 pain domain [40].

The French multicenter phase III MIRO trial [12, 13] has randomised patients to either hybrid oesophagectomy (laparoscopic gastric mobilisation and open right thoracotomy) or open oesophagectomy. The MIRO trial tested the impact of laparoscopic gastric conduit creation with open thoracotomy (hybrid procedure) on major 30-day postoperative morbidity, especially on pulmonary complications. It hypothesised that hybrid MIO may decrease major postoperative morbidity without compromising oncological outcomes through an easily reproducible surgical procedure. Secondary objectives assessed the overall 30-day morbidity, 30-day mortality, disease-free and overall survival, quality of life and medico-economic analysis. The trial randomly assigned 104 patients to open oesophagectomy and 103 to a hybrid approach group. Sixty-seven (64.4%) patients in the open group had major postoperative morbidity compared with 37 (35.9%) in the hybrid group (OR 0·31, 95% CI 0·18–0·55; p = 0·0001). Thirty-one (30.1%) patients after an open operation had major pulmonary complications compared with 18 (17.7%) after a hybrid approach (p = 0·037), whereas the 30-day mortality rate was 1.9% vs. 1.0%, respectively. Medical related postoperative complications were significantly lower in the hybrid approach (19.6% vs. 39.8%), whereas the surgical related complications were not different between the groups even if favouring the hybrid group (14.7% vs. 20.4%). Regarding oncological outcomes, the 2-year overall survival rate (76.7% vs. 63.2%, p = 0.127) and disease-free survival rate (63.1% vs. 54.5%, p = 0.224) had not significantly improved in the MIO group. The MIRO results provide further evidence that a hybrid minimally invasive approach reduces the short-term insult of oesophagectomy without a negative impact on long-term oncological outcomes.

8.6 Total Versus Hybrid Oesophagectomy

Many authors reporting total minimally invasive approaches describe most as modifying the technique for avoiding the complexity of an intrathoracic anastomosis and consequently performing systematically the anastomosis in the neck. Others describe hybrid procedures where one stage of the operation is performed—either by thoracoscopy or laparoscopy and the other by conventional open surgery. The thoracoscopic approach is the widely-used hybrid procedure reported, being based on the hypothesis that thoracic-incision-related pain is the prominent factor responsible for postoperative pulmonary complications. However, the hybrid thoracoscopic approach calls for a three-stage procedure with a cervical anastomosis and subsequent morbidity. Others have reported a hybrid approach with laparoscopic gastric mobilization and open thoracotomy. This being based on the hypothesis that the high rate of postoperative complications after oesophagectomy—especially respiratory complications—is more related to the combination of two surgical incisions on both sides of the diaphragm than to the thorax opening, and hence is responsible for deterioration of the ventilatory mechanisms [33].

Even with only one phase of the operation being minimally invasive, yet blood loss, overall morbidity and respiratory complications were still found to be lower in retrospective comparative studies comparing open versus Hybrid MIO (HMIO) [8, 41]. This is consistent with open versus totally MIO analysis, and highlights the purported advantages of applying a minimally invasive approach to oesophagectomy. Postoperative mortality was also found to be significantly reduced with laparoscopic gastric mobilization [33, 38], offering similar oncological outcomes.

Looking at the two randomized trials reported to date, the TIME trial comparing totally MIO versus open [11] and the MIRO trial comparing HMIO and open oesophagectomy [12, 13], similar conclusions can be drawn. We see comparable odd ratios reported for decreasing postoperative complications that were 0.30 [0.12–0.76] in the TIME trial versus 0.31 [0.18–0.55] in the MIRO trial. Regarding oncological results, only the MIRO trial reported long-term outcomes that were not significantly different between groups, slightly favouring HMIO [12, 13].

HMIO—especially laparoscopic gastric mobilization—appears easy, reproducible, and not requiring modification of the surgical technique; It appears feasible despite the tumour or patients' characteristics or the centre experience, and does not compromise carcinologic resection, necessitating probably a little learning curve.

Totally MIO increases complexity and consequently brings a higher potential for error, requires according most reports modifications of the surgical technique with the need for a cervical anastomosis and its proper morbidity, needs very experienced hands, is time-demanding and probably is less easily reproducible. In addition, oncological safety of totally MIO is still a concern at present time, with few data on long-term oncological outcomes reported, especially for locally advanced tumours.

Scientific comparison between MIO and HMIO is of huge scientific interest. However, considering the limited results of randomized trials published, we can expect small differences while requiring a very large number of patients to be enrolled. More than placing MIO and HMIO in opposition, probably the more interesting course could be to choose one or the other approach according to the patient's profile, the tumour extension and the centre/surgeon expertise.

Conclusions

MIO has been gaining in popularity but—as seen with open surgery—no consensus has been reached regarding the superiority of any particular MIO adaptation. Even if some large comparative studies show a significantly better postoperative course following MIO harbouring no compromise of oncological outcomes, yet more data from randomized trials is needed. Randomized trials, however, have drawbacks due to the wide variety of techniques available, the heterogeneity in surgeons' preferences, the relative low number of procedures performed, the complexity of such surgery, and the variety and definition of postoperative complications after oesophagectomy. Certainly, the positive results of the TIME and the soon to be published MIRO trial add credence to what many surgeons find intuitive—that a less invasive approach could reduce morbidity after oesophagectomy. As the rates of postoperative mortality have fallen in specialist centres, our focus must turn to minimising the traditionally high level of morbidity associated with this operation.

To date, the data coming from non-randomized studies do suggest MIO is safe, and at least is comparable to open resection for both surgical and oncological outcomes. Data from meta-analyses suggest that MIO may have advantages in terms of less blood loss, less time in intensive care, fewer pulmonary complications and shorter hospital stay. However, the effect of MIO on quality of life and return to normal activity needs to be confirmed and medico-economic analyses need to be performed. Hence, requiring more large randomized controlled trials of oesophagectomy.

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