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REVIEW

Minimally invasive esophagectomy for esophageal cancer in the People's Republic of China: an overview

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Chengchu Zhu[1]
Ketao Jin[2]

[1]Department of Cardiothoracic Surgery, [2]Department of Surgical Oncology, Taizhou Hospital, Wenzhou Medical College, Linhai, Zhejiang, People's Republic of China

Abstract: Since its introduction in the People's Republic of China in 1992, minimally invasive esophagectomy (MIE) has shown the classical advantages of minimally invasive surgery over its open counterpart. Like all pioneers of the technique, cardiothoracic surgeons in the People's Republic of China claim that MIE has a lower risk of pulmonary infection, faster recovery, a shorter hospital stay, and a more rapid return to daily activities than open esophagectomy, while offering the same functional and oncologic results. There has been burgeoning interest in MIE in the People's Republic of China since 1995. The last decade has witnessed nationwide growth in the application of MIE and yielded a significant amount of scientific data in support of its clinical merits and advantages. However, no prospective randomized controlled trials have actually investigated the benefits of MIE in the People's Republic of China. Here we review the current data and state of the art MIE treatment for esophageal cancer in the People's Republic of China.

Keywords: esophagectomy, minimally invasive esophagectomy, esophageal cancer, review

Introduction

The global incidence of esophageal cancer has increased by 50% in the past two decades.[1,2] Advances in neoadjuvant and adjuvant chemotherapy and chemoradiotherapy have led to increasingly multimodal treatment for patients with esophageal cancer, which has decreased the rate of local recurrence and improved long-term survival for some patients. However, surgical resection with radical lymphadenectomy is regarded as one of the curative options for resectable esophageal cancer.[3–6] Frequently, due consideration of surgical resection may not be given because of concerns with regard to the morbidity of open esophagectomy.

In an effort to decrease the morbidity associated with open esophagectomy, Chinese surgeons have adopted a minimally invasive approach to esophageal resection. Because of the potential advantages, including avoiding thoracotomy and laparotomy and reducing the rate of pulmonary infections (thus reducing the inpatient stay),[7,8] minimally invasive esophagectomy (MIE) was introduced into clinical practice in Taiwan[9] in 1992 at the same time as in Western countries,[10–12] was gradually implemented, and is now a commonplace procedure in the People's Republic of China (Figure 1), including in Beijing,[13–15] Jinan in Shandong Province,[16] Zhengzhou in Henan Province,[17] Nanjing in Jiangsu Province,[18] Shanghai,[19–30] Taizhou in Zhejiang Province,[31–33] Fuzhou in Fujian Province,[34–36] Taipei[9] and Taichung[37] in Taiwan, Hongkong,[38–40] Guangzhou in Guangdong Province,[41,42] Changsha in Hunan Province,[43] Chongqing,[44,45] and Chengdu[46–48] and Nanchong[49] in Sichuan Province. There has been burgeoning interest in MIE since

Correspondence: Ketao Jin
Department of Surgical Oncology, Taizhou Hospital, Wenzhou Medical College, 150 Ximen Road, Linhai, Zhejiang 317000, People's Republic of China
Tel +86 576 8519 9876
Fax +86 576 8519 9876
Email jinketao2001@zju.edu.cn

Figure 1 Fifteen national areas implementing minimally invasive esophagectomy in the People's Republic of China.

Notes: High-volume centers: First Affiliated Hospital, School of Medicine, Peking University and Chaoyang Hospital, Capital Medical University in Beijing; Shandong Provincial Hospital, Shandong University in Jinan; The Affiliated Tumor Hospital, Zhengzhou University in Zhengzhou; Jiangsu Provincial Cancer Hospital in Nanjing; Zhongshan Hospital, Fudan University, The Cancer Hospital of Fudan University, Changzheng Hospital, Second Military Medical University and Shanghai Chest Hospital, Shanghai Jiaotong University in Shanghai; Taizhou Hospital, Wenzhou Medical College in Taizhou; Affiliated Union Hospital of Fujian Medical University and Fujian Provincial Tumor Hospital of Fujian Medical University in Fuzhou; Chang Gung Memorial Hospital, Chang Gung Medical College in Taipei; Tungs' Taichung MetroHarbor Hospital in Taichung; University of Hong Kong Medical Centre, Queen Mary Hospital and The Chinese University of Hong Kong, Prince of Wales Hospital in Hongkong; Nanfang Hospital, Southern Medical University and Cancer Center, Sun Yatsen University in Guangzhou; Second Xiangya Hospital of Central South University in Changsha; Daping Hospital, Third Military Medical University in Chongqing; West China Hospital, Sichuan University in Chengdu; The Second Clinical Institute, North Sichuan Medical College in Nanchong.

it was first described in Taiwan in 1995[9] and in the People's Republic of China in 1999.[13] The last decade has witnessed nationwide growth in use of MIE, yielding a significant amount of scientific data to support its clinical merits and advantages. Here we review the current data and state of the art for MIE in the treatment of esophageal cancer in the People's Republic of China.

Literature on MIE in the People's Republic of China

The current literature was reviewed by searching the PubMed/Medline database from January 1992 to December 2012 using keywords such as "minimally invasive oesophagectomy", "MIE", and "China". Sixty-one full articles were found to be relevant to MIE (Figure 2). A total of 33 publications (54.1%) were in English. However, nearly half of all relevant clinical reports (28, 45.9%) were published in Chinese, despite the fact that it has been necessary to report the current status of MIE as performed in the People's Republic of China to cardiothoracic surgeons worldwide. A marked increase in the number of papers dedicated to MIE was observed from 2010 to 2012 (Figure 2), which probably reflects increased research interest among the surgical community and wider clinical application of this patient-friendly approach.

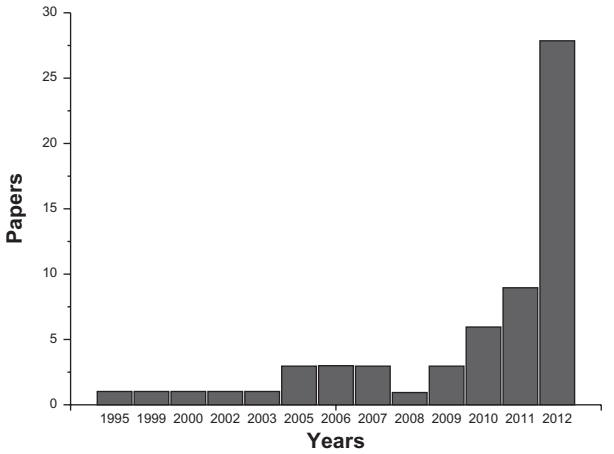

Figure 2 Numbers of papers related to minimally invasive esophagectomy performed in the People's Republic of China identified in the PubMed/Medline database, using keywords such as "minimally invasive oesophagectomy", "MIE", and "China".

Operative data on MIE

Key outcomes of the major studies are summarized in the Tables 1 and 2. Thirty-two relevant papers, consisting of prospective and retrospective studies, were identified. Eight papers directly compared open oesophagectomy and MIE, and[16,17,21,30,31,39,41,48] five of these involved studies performed prospectively.[16,31,39,41,48] Common outcome measures included operative data (operative time, blood loss, conversion rate), morbidity (duration of intensive care and total hospital stay), complications (pulmonary complications, anastomotic leaks, chylothorax), mortality data, and follow-up periods. Neoadjuvant treatment numbers were included for each study.

Surgical approaches

Surgical approaches for MIE performed by Chinese cardiothoracic surgeons are multiple and complicated. As listed in Table 1, the majority of centers use mainly total MIE (laparoscopic and thoracoscopic esophagectomy), whereas hybrid MIE (thoracoscopy and laparotomy/laparoscopy and thoracotomy) is used in routine practice in some centers. At our center, we originally used hybrid MIE[31] but more recently transitioned to a minimally invasive modified McKeown 3-incision total MIE (laparoscopic and thoracoscopic esophagectomy) in 2010.[32,33]

Table 1 Survey over major reports of minimally invasive esophagectomy in the People's Republic of China: operative data

Reference	PS/RS	Patient (n)	AC	TC	AS	Position	OT (min)	BL (mL)	C, n (%)
Liu et al[9]	RS	20	Open	MI	Thoracic	Left Lateral	280	250	NA
Li et al[14]	PS	6	MI	MI	Thoracic	Left Lateral	260 ± 42	520 ± 160	0
Li et al[15]	RS	6	MI	MI	Thoracic	Left Lateral	380	300	0
Du et al[16]	PS	45	Open	HA	Cervical/ thoracic	Left Lateral	29 ± 5 (TC)	93 ± 19 (TC)	NA
		27	Open	MI	Cervical	Left Lateral	425 (240–538)	400 (100–1200)	1 (4)
Liu et al[17]	RS	98	MI	MI	Cervical	Left Lateral	134.5 ± 42.3	85.1 ± 32.8	NA
Hou et al[18]	RS	41	MI	MI	Cervical	Prone	230 (170–310)	275 (100–320)	NA
		41	MI	MI	Cervical	Left Lateral	280 (190–380)	360 (120–670)	NA
Wu et al[20]	PS	32	Open	MI	Cervical	Supine	180	218	0
		8	MI	MI	Cervical	Supine	220	100	0
Zhou et al[22]	PS	30	Open	MI	Cervical	Left Lateral	225 (195–290)	250 ± 52.2	1 (3)
Tan et al[23]	RS	36	Open	MI	Cervical	Left Lateral	250 (190–330)	165 (100–350)	0
Wang et al[24]	PS	27	MI	MI	Cervical	Left Lateral	267 ± 51	327 ± 83	NA
Feng et al[25]	PS	27	MI	MI	Cervical	Supine	194.4 ± 26	215 ± 111.6	0
		27	MI	MI	Cervical	Left Lateral	228.1 ± 35.8	142.6 ± 51.3	0
Wang et al[26]	RS	48[a]	MI	MI	Cervical	Left Lateral	279 ± 64	359 ± 156	NA
		49[b]	MI	MI	Cervical	Left Lateral	266 ± 56	336 ± 130	NA
Feng et al[27]	RS	52	MI	MI	Cervical	Left Lateral	82 ± 17 (TC)	139 ± 54 (TC)	0
	RS	36	MI	MI	Cervical	Prone	70 ± 20 (TC)	100 ± 52 (TC)	0
Shen et al[28]	RS	76	MI	MI	Cervical	Prone	89 ± 32 (TC)	152 ± 108	0
Feng et al[29]	PS	41	MI	MI	Cervical	Decubitus	217 ± 32	142 ± 49	1 (2.4)
	PS	52	MI	MI	Cervical	Prone	202 ± 21	123 ± 56	0
Wang et al[30]	RS	260	MI/O	MI	Cervical	Left Lateral	105 ± 30 (TC)	95 ± 48 (TC)	NA
Zhu et al[31]	PS	25	Open	MI	Thoracic	Left Lateral	88 ± 15 (TC)	280 ± 132 (TC)	NA
Chen et al[32]	PS	67	MI	MI	Cervical	Left Lateral	274 ± 15	225 ± 31	NA
Zhu et al[33]	PS	11	MI	MI	Cervical	Left Lateral	242.3 ± 27.0	168.2 ± 95.6	NA
Lin et al[34]	RS	80	MI	MI	Cervical	Left Lateral	NA	100–250	6 (8)
Liu et al[35]	RS	297	MI	MI	Cervical	Left Lateral	242.3 ± 58.7	NA	1 (3)
Lin et al[36]	RS	150	MI	MI	Cervical	Left Lateral	258 ± 45	207 ± 130	6 (4)
Cense et al[38]	PS	30	Open	MI	Cervical	Left Lateral	400 (180–570)	700 (164–3000)	2 (7)
Law et al[39]	PS	30	Open	MI	Thoracic	Left Lateral (29)/ prone (1)	392 (180–570)	700 (164–3000)	2 (6.7)
Wong et al[40]	PS	12	MI	MI	Thoracic	Supine	510 (300–660)	500 (250–2500)	1 (8)
Wang et al[41]	PS	33	MI	MI	Cervical	Na	NA	NA	NA
Xie et al[42]	RS	100	MI	MI	Cervical	Left Lateral	310	200	4 (4)
Yuan et al[43]	PS	32	MI	MI	Cervical	Left Lateral	290.8 ± 36.9	NA	NA
		36	Open	MI	Cervical	Supine	249.0 ± 31.0	NA	NA
Guo et al[44]	RS	89	Open	MI	Cervical	Left Lateral	323.7 ± 50.3	307.8 ± 162.7	8 (9.0)
Guo et al[45]	RS	135	Open	MI	Cervical	Left Lateral	334 ± 51.1	349.3 ± 164.8	10 (7.4)
Zhang et al[46]	RS	160	MI	MI	Cervical	Prone	230–780	20–4000	9 (5.6)
Gao et al[48]	PS	96	MI	MI	Cervical	Left Lateral	330.2 ± 36.7	346.7 ± 41.1	0

Notes: [a]Retrosternal route of gastric tube reconstruction; [b]prevertebral route of gastric tube reconstruction.
Abbreviations: PS, prospective study; RS, retrospective study; AC, abdominal component; TC, thoracic component; AS, anastomosis site; OT, operation time; BL, blood loss; C, conversion rate; MI, minimally invasive; O, open; NA, not available; HA, hand-assisted.

Operative time and blood loss

Operative time varied significantly between the studies, reflecting the type of MIE performed as well as accumulated experience and technical skills (Table 1). Blood loss also varied significantly from center to center, comprising around 100–700 mL (Table 1). Major blood loss and need for blood transfusion in particular increased the risk of postoperative morbidity and mortality.

Conversion to open esophagectomy

The conversion rate reported in the literature is in a range of 0%–9.7% (Table 1). However, with surgical experience, the conversion rate reduces and currently does not exceed 5% in expert centers in the People's Republic of China. The main reason for conversion was bleeding. It is not appropriate to consider conversion from MIE to open esophagectomy as a failure because patient safety and the

Table 2 Survey of major reports of minimally invasive esophagectomy in the People's Republic of China: mortality, morbidity, and postoperative complications

Reference	Patient (n)	AL, n (%)	PC, n (%)	Ch, n (%)	ICUS (d)	HS (d)	30-DM	Mortality, n (%)	FP (m)
Liu et al[9]	20	0	0	0	NA	19	NA	NA	11.5
Li et al[14]	6	0	NA	NA	0	17	NA	NA	2.5
Li et al[15]	6	0	0	0	NA	NA	NA	NA	NA
Du et al[16]	45	NA	NA	NA	NA	10.0 ± 1.0	NA	NA	NA
Liu et al[17]	98	2 (2.0)	10 (10.2)	3 (3.1)	NA	12.7 ± 3.5	1	NA	NA
Hou et al[18]	41	1 (2.4)	2 (4.9)	0	NA	NA	NA	NA	15.7
	41	1 (2.4)	1 (2.4)	2 (4.9)	NA	NA	NA	NA	16.3
Wu et al[20]	32	3 (9.4)	1 (3.1)	1 (3.1)	2.2	11.6	NA	NA	NA
	8	1 (12.5)	0	0	1.2	10.6	NA	NA	NA
Zhou et al[22]	30	2 (6.7)	2 (6.7)	1 (3.3)	NA	11.7 ± 6.3	0	0	NA
Tan et al[23]	36	5 (13.9)	1 (2.8)	1 (2.8)	NA	8.7	0	0	NA
Wang et al[24]	27	5 (18.5)	1 (3.7)	2 (7.4)	2.3 ± 1.7	NA	NA	NA	NA
Feng et al[25]	27	5 (18.5)	7 (25.9)	0	3.1 ± 4.4	11.1 ± 6.6	1	NA	36
	27	4 (14.8)	4 (14.8)	1 (3.7)	1.9 ± 4.2	13.3 ± 10.6	0	NA	36
Wang et al[26]	48	10 (20.8)	2 (4.2)	1 (2.1)	2.5 ± 1.7	NA	0	NA	NA
	49	3 (6.1)	6 (12.2)	1 (2.0)	2.8 ± 1.9	NA	0	NA	NA
Feng et al[27]	52	8 (15.4)	5 (9.6)	2 (3.8)	1.3 ± 3.5	13.6 ± 9.3	NA	NA	NA
	36	2 (5.6)	1 (2.8)	0	1.1 ± 1.5	10.9 ± 6.0	NA	NA	NA
Shen et al[28]	76	16 (21.1)	5 (6.6)	1 (1.3)	NA	19.2 ± 16.3	NA	0	NA
Feng et al[29]	41	9 (22.0)	4 (9.8)	NA	3.5 ± 1.3	17.4 ± 12.5	NA	NA	NA
	52	4 (7.7)	5 (9.6)	NA	1.5 ± 1.1	11.4 ± 6.8	NA	NA	NA
Wang et al[30]	260	26 (10)	22 (8.5)	3 (1.2)	NA	14.3 ± 7.5	NA	2 (7.7)	NA
Zhu et al[31]	25	1 (4)	NA	NA	NA	10.9 ± 2.5	NA	NA	NA
Chen et al[32]	67	NA	7 (10.4)	NA	NA	11.5 ± 1.6	NA	NA	14.0 ± 2.2
Zhu et al[33]	11	2 (18.2)	3 (27.3)	NA	NA	18.9 ± 10.3	NA	NA	4.5
Lin et al[34]	80	1 (1.3)	NA	2 (2.5)	NA	NA	NA	NA	NA
Liu et al[35]	297	9 (3.0)	41 (18.8)	NA	NA	17.4 ± 9.8	NA	NA	NA
Lin et al[36]	150	9 (6.0)	17 (11.3)	5 (3.3)	NA	NA	2 (1.3)	9 (6)	3–22
Cense et al[38]	30	1 (3.3)	12 (40)	NA	NA	NA	NA	NA	NA
	27	1 (3.7)	13 (48.1)	NA	NA	NA	NA	2 (7)	NA
Law et al[39]	30	1 (3.3)	12 (40)	0	NA	NA	1	NA	NA
Wong et al[40]	12	1 (8.3)	2 (17)	NA	2	41	0	0	NA
Wang et al[41]	33	1 (3.0)	0	0	NA	NA	NA	NA	NA
Xie et al[42]	100	11 (11)	13 (13)	3 (3)	1 (1)	12 (12)	NA	NA	NA
Yuan et al[43]	32	2 (6.3)	NA	NA	1	11.1 ± 1.3	0	NA	NA
	36	5 (13.9)	NA	NA	1	11.6 ± 1.7	0	NA	NA
Guo et al[44]	89	6 (6.7)	4 (4.5)	4 (4.5)	NA	15.2 ± 9.8	NA	NA	NA
Guo et al[45]	135	9 (6.7)	7 (5.2)	8 (5.9)	NA	NA	NA	NA	NA
Zhang et al[46]	160	21 (13.1)	25 (15.6)	4 (2.5)	1	13.1	2 (1.3)	4 (2.5)	NA
Gao et al[48]	96	7 (7.3)	13 (13.5)	1 (1.1)	19.2 ± 3.5	12.6 ± 8.8	NA	2 (2.1)	NA

Abbreviations: AL, anastomotic leaks; PC, pulmonary complication; Ch, chylothorax; ICUS (d), intensive care unit stay (days); HS (d), hospital stay (days); 30-DM, 30-day mortality; FP (m), follow-up period (months); NA, not available.

oncologic integrity of the procedure should be of supreme importance.

Mortality, morbidity, and postoperative complications

Mortality rates following total MIE vary between 0% and 7.7% (Table 2), which compares favorably with an open transthoracic procedure mortality rate of 9.2% and an open transhiatal procedure mortality rate of 7.2%.[50] However, at least half of the patients who undergo open oesophagectomy, performed through a right thoracotomy and laparotomy, are at risk of developing pulmonary complications requiring a protracted stay in intensive care, with consequences for quality of life during convalescence.[50] Anastomotic leak is one of the most feared complications of MIE. From the operative data, the MIE leakage rate was in the range of 0%–20.8% (Table 2), which is comparable with the leakage rates reported for open oesophagectomy.[51]

Median duration of postoperative stay in intensive care following MIE was one day in the majority of studies (Table 2). MIE is associated with a significant reduction in hospital stay, with a mean postoperative stay of 12 days (Table 2).

Outcomes

There is little survival data for MIE available in the People's Republic of China. Only one study reported overall survival after MIE.[25] Feng et al reported median survival for patients in a thoracoscope-assisted transthoracic esophagectomy group and in a mediastinoscope-assisted transhiatal esophagectomy group of 34.4 months and 36.8 months, respectively.[25] There do not appear to be any prospective, randomized, controlled trials comparing the oncologic outcome of MIE with that of open esophagectomy. The present knowledge is based mainly on short-term, nonrandomized comparative studies or historical comparisons with outcomes of open surgery.[31,39,41,48]

Conclusion

In conclusion, MIE is becoming more popular in the People's Republic of China now that Chinese cardiothoracic surgeons are receiving adequate training in major centers. Use of the technique is growing in the People's Republic of China, as confirmed by the increasing number of recently published papers on MIE. However, no prospective, randomized, controlled trials have investigated the benefits of MIE in this country. Such trials, directly comparing MIE and open approaches, are urgently needed.

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Disclosure

The authors report no conflicts of interest in this work.

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