Intraoperative Disasters During Minimally Invasive Esophagectomy

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Abstract

Background: Intraoperative disasters remain a serious concern during Minimally Invasive Esophagectomy (MIE), however, it has never been properly reported. The aim of the study was to analyze the incidence, types, and management of intraoperative disasters encountered during MIE in a Tertiary Cancer Hospital in Nepal.

Methods: A retrospective review of prospectively maintained database of 303 consecutive MIE cases for esophageal and gastroesophageal junction cancer performed at BP Koirala Memorial Cancer Hospital was conducted. Patients who underwent McKewon's MIE (n=260), Ivor-Lewis (n=4) MIE and Transhiatal MIE (n=39) were included in the study. Intraoperative disasters were defined as catastrophic events leading to major bleeding or injury to vital structures during surgery.

Results: Major intraoperative complications were observerved in 9 patinets (2.9%). Tracheo-bronchial (n=2), Thoracic duct (n=2), pulmonary parenchymal (n=2), SVC (n=1), and aortic (n=1) were detected intraoperatively and were managed with suture repair. One splenic injury was controlled with electrocauterization. None of the patients required conversion to open surgery. There was one 90-day mortality (1/9; 11%) among patients with intraoperative complications.

Conclusion:
Identification and prompt management of intraoperative complications are critical in minimizing post operative mortality. Our study may serve as a reference to compare and evaluate performance of MIE for cancer in Nepalese context.

Keywords: Esophageal cancer, McKeown's esophagectomy, Intraoperative disasters, Minimally invasive surgery

Introduction

Esophageal cancer is a major health problem, especially in Eastern Asia, Eastern Africa, southern Africa and South-central Asia.[1] Globocon 2022 has shown the esophageal cancer to be 7th leading cause of cancer deaths worldwide. [2] In Nepal, esophageal cancer ranks 18th by incidence and 15th by mortality.[2] Currently, esophagectomy in combination with perioperative chemotherapy or preoperative chemoradiation remains the standard of care. Esophagectomy is categorized as a higher risk procedure secondary both to the technical complexity of the procedure and the high rates of peri-operative complications, which occur in approximately 60% of cases.[3]

The two randomized trials TIME[4] and MIRO[5] showed reduced incidence of post-operative complications for Minimally Invasive Esophagectomy (MIE). Major pulmonary complications were 30% and 18%, respectively in open and hybrid MIE, respectively (MIRO Trial). In TIME trial, pulmonary infections were noted in 34% and 9% in open and MIE approaches, respectively. Hence, MIE has been established as a standard of care currently. Nevertheless, MIE is associated with a significant

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learning curve and generally requires 50–70 cases for proficeincy.[6-8]

Postoperative complications for MIE have been recently reviewed in a meta-analysis and by a multicentric study that benchmarked its outcomes.[9,10] The available literature focuses mostly on postoperative outcomes. Though several studies on MIE mention intraoperative (IO) complications [11], the literature on these complications is limited. It is obvious that IO disasters can lead to postoperative complications. There is negligible literature documenting IO disasters during MIE in Nepal. This study aims to fill that gap by analyzing 303 consecutive MIE cases, focusing on IO disasters, management strategies, and lessons learned.

Methodology

Patient:

Patients with cancer of the thoracic esophagus and gastroesophageal junction (GEJ, Siewert type I/ II) undergoing MIE at Thoracic Unit of BP Koirala Memorial Cancer Hospital (BPKMCH) between 2001 and 2025 were evaluated for major IO complications. This was a retrospective analysis of prospectively maintained database.

Major IO complications were defined as

1. IO Loss of planned conduit
2. Sudden blood loss of > 500 ml
3. Erroneous injury/ transection of vascular structures
4. Injury to other organs: lung, heart, bowel , liver, spleen, thoracic duct, trachea and bronchi

Anaesthesia related and non-surgical complications e.g. arrhythmina, hypotension, pulmonary embolism, Myocardial infarction etc, were excluded.

The study was approved by the Institutional Review Committee, BPKMCH. Because individual patients could not be identified, the need for patients' consent was waived.

Surgrical technique:

Patients with GEJ tumors of Siewert type II (n=45) underwent Transhiatal MIE (n=39), Ivor-Lewis MIE (n=4) and McKewon's MIE (n=2). During Transhiatal MIE, five ports were utilized for complete gastric mobilization of the stomach and tumor along with laparoscopic mobilization of esophagus upto the level of carina. A D2 abdominal and lower mediastinal lymphadenectomy was performed. In Ivor-Lewis MIE, thoracic part of resection and anastomosis was done through a 4 cm utility incision in lateral position under a single lung ventilation. An infra-carinal two-field (2-FD) lymphadenectomy was performed.

Patients with tumors of thoracaic esophagus including Siewert type I GEJ underwent McKewon's MIE (n=110) or McKewon's Hybrid MIE (n=148). Thoracic part with esophageal and tumor resection was done in prone or semi-prone position with Capnothorax using three port technique in all cases. During McKeown's MIE, both thoracic and abdominal steps were performed by minimally invasive approach. In 148 cases of Hybrid approach, abdominal part for gastric/ colonic conduit creation was done with open laparotomy. A 2-FD (infra-carinal), extended 2-FD (infracarinal + left 106 recurrent laryngeal node), total mediastinal 2-FD (infracarinal + 106 recurrent laryngeal nodes bilaterally) or 3-FD (addition of cervical nodal dissection) type of nodal dissection was performed as per the description of the surgeon. The main part of tumor mobilization and resection was performed by the senior surgeon of the team (corresponding author) in all cases.

IO complications:

Only major IO complications were included. They were categorized as vascular, major airway, pulmonary, thoracic duct and solid visceral injuries. Type of repair, outcome, conversion rate and 90-day mortality were recorded. Minor surgical complications e.g. minor pulmonary tear or bronchial/ esophageal bleed which resolve by itself were excluded.

Stastical analysis:

Descriptive statistics were summarized with frequencies and percentages for categorical varaibles and mean for continuous variables using SPSS version 26.

Results

In a span of 24 years (2001-2025), 732 radical esophagectomies were performed at BPKMCH (Thoracic Unit). Three hundred and three patients underwent MIE. Demographic parameters have been represented in Table 1.

Table 1. Demographics.

Parameters (n=303)	
Age (mean)	59 (28-84) years
Male	167 (55%)
Female	136 (45%)
Smoker	208 (69%)
Dysphagia Grade 0 Grade 1 Grade 2 Grade 3 Grade 4	299 (98.5%) 3 4 2 196 24
Duration of dysphagia	4.5 m
Weight loss (mean)	7.7 kg
Average dissected nodes	20
Tumor location Upper Middle GEJ I GEJ II	 11 (3.6%) 119 (39.3% 128 (42.2%) 45 (14.9%)
Histology Squamous cell carcinoma (SCC) Adenocarcinoma Neuroendocrine carcinoma Leiomyosarcoma	 213 (70.3%) 85 (28%) 1 (.3%) 4 (1.3%)

The majority had the the epicenter of tumor at distal esophagus (GEJ type I, n=128) followed by middle (n=119), GEJ type II (n=45) and upper esophagus (n=11). SCC was the most common histological type (n=213).

Tables 2 and 3 show the treatment and type of lymphadenectomy received by the patients, respectively. Radical lymphadenectomy was done in 278 (91.7%) patients.

Table 2. Treatment.

Treatment	N (%)
Surgery	115 (37.9%)
Perioperative CT- Surgery*	79 (26.1%)
Preoperative CTRT-Surgery†	72 (23.8%)
Surgery- CTRT‡	37 (12.2)

*Perioperative chemotherapy and surgery
†Preoperative chemoradiation followed by surgery
‡Surgery followed by chemoradiation

Table 3. Lymphadenectomy.

Lymph node technique	N (%)
Sampling	25 (8.3%)
2-FD	161 (53%)
Extended 2-FD	13 (4.3%)
Total 2-FD	62 (20.5%)
3-Fd	3 (1%)
Abd D2+lower med	39 (12.9%)

Mean operative time was 241 minutes, mean tumor length was 5 cm and intra operative blood loss was 250 ml. Stomach was used in 301 cases whereas 2 cases required colonic interposition. R0 and R+ resection were obtained in 87.8% and 6%, respectively.

For the whole group (n=303), five (1.6%) patients had 90-day post operative mortality.

IO complications have been observed in 9 (2.9%) patients (Table 4). Two IO complications were observed during Transhiatal MIE (0.6%). One patient had splenic injury during transhiatal MIE, which was controlled by bipolar cauterization. Another patient had avulsion of esophageal artery from the aorta leading to profuse hemorrhage which required suturing with 4/0 polypropelene thread.

During thoracoscopic phase of Mckeown's MIE, there were altogether seven events comprising 2.3% (thoracic duct injury:2, major airway injury: 2, pulmonary parenchymal injury: 2 and SVC injury:1).

Table 4. IO complications.

IO complications	N
Pulmonary parenchymal injury	2
Splenic injury	1
Thoracic duct injury	2
SVC injury	1
Aortic injury	1
Tracheal injury	2

Mean intraoperative blood loss was 650 ml (200-1200 ml) for vascular injuries and 340 ml (150-520 ml) for visceral injuries.

A detailed description of all complications has been presented in Table 5. One patient with left bronchial injury due to tumor invasion died on 9th post operative period due to progressive pneumonia (in-hospital mortality: 1/9= 11%). There were no more 90-day mortality.

Table 5. Details of IO complications.

Case	Clinical stage	Rx	Surgery	Lymphadenectomy	Path Response	IO complication	Management	Resection status	Outcome
49/F, SCC mid third	IVA	CT-S	Hybrid McK*	2-FD	stable	Left main bronchus rupture due to tumor invasion	Suture repair with pleural buttressing	R+	Post op death
57/F SCC mid third with skip intramucosal lesions	IIIB	CT-S	Hybrid McK	Total 2-FD	stable	Tracheal rupture due to ETT overinflation‖	Suture repair	R0	Uneventful
57/M SCC lower third	IIIA	CTRT-S	McK MIE†	Total 2-FD	PR‡	Splenic injury	Electrocauterization	R0	Uneventful
58/M SCC lower third	IIIA	CT-S	McK MIE	2-FD	PR	Lung parenchyma due to obliterated thorax	Suture repair	R0	Uneventful
61/M SCC mid third	IB	S	Hybrid McK	Total 2-FD	NA	Thoracic duct injury	Clipping (at supradiaphragmatic location and at the site of injury)	R0	Uneventful
69/M adeno ca GEJ-I	IIIB	S-CT	Transhiatal MIE	D2+low med	NA§	Aortic	Suturing	R0	Uneventful
79/M SCC mid third	IIB	CTRT-S	McK MIE	Total 2-FD	PR	SVC injury due to adhesions	Suturing	R0	Uneventful
66/F SCC upper third	IIIA	CTRT-S	Hybrid McK	Total 2-FD	PR	Thoracic duct due to desmoplastic reaction	Clipping (at supradiaphragmatic location and at the site of injury	R0	Uneventful
72/ F SCC mid third	IIIB	CTRT-S	McK MIE	Total 2-FD	PR	Lung parenchyma due to obliterated thorax	Suturing	R0	Uneventful

*Hybrid McKeown's MIE †McKeown's MIE ‡Partial response §Not applicable ‖Endotracheal tube

Discussion

Esophagus has got a complex anatomy due to its close vicinity to major vessels and airway. An understanding of these relationships is crucial in minimizing IO disasters, both technical and non-technical. Non-technical events e.g. arrhythmia, pulmonary embolism, and myocardial infarction cannot be controlled by surgeon. Major technical/surgeon-related complications, which are the focus of this article are fortunately few but are associated with significant post-operative morbidity and even mortality. The literature mostly reports post operative complications. There are only handful of studies analyzing IO complications and even lesser studies addressing them during MIE.

The incidence of both airway and vascular injury is low in open transhiatal esophagectomy (THE), occurring in around 1% of cases.[12] In analysis of 2007 cases of open THE (76% cases for malignancy) by Orringer and team, there were 4 (0.19%) intraoperative deaths due to uncontrollable hemorrhage during mediastinal esophageal mobilization. They reported major intraoperative bleed (>4000 ml) in 8 additional patients which required thoracotomy for control.[13]

Tracheo-bronchial injury occurs most commonly secondary to desmoplastic reaction after preoperative chemoradiation therapy or unexpected invasion by the tumor. Common sites of injury are membranous part of trachea and left main bronchus, particularly in cases of upper esophageal tumors. Therefore, a pre-operative bronchoscopy is recommended for upper esophageal tumors to exclude tumor invasion into the trachea and main bronchi prior to surgery. A transthoracic approach is recommended in the setting of suspected involvement.[14] In cases of tracheo-bronchial injury, a primary repair is required with 3/0 or 4/0 absorbable suture. The repair should be buttressed with locally available pleura, pericardium, muscle flap, omentum, or even gastric conduit. In later case, care must be taken to avoid proximity of the gastric tube staple line to the repair to avoid fistulization.[15]

Similarly, vascular injury can occur during abdominal, mediastinal dissection, or cervical stage of dissection. Such injuries have been rarely reported in the literature (0.01% incidence)—many in case

reports only or in retrospective studies.[16] The reason seems to be due to a significant underreporting and lack of standardized definitions. Simple suturing generally is enough to control bleeding.

Thoracic duct injury, leading to post operative chylothorax is a more common complication during esophagectomy. The incidence ranges from 0.4% to 4% in the literature.[17,18] A difficult mediastinal dissection and an upper and mid esophageal tumor may lead to injury of thoracic duct. Complete pathological response of the tumor to preoperative chemo or chemoradiation has been found to reduce the chances of post operative chylothorax.[19]

In a multi-centric review of 2862 MIE patients from ten European esophageal surgery centers in eight European countries, 98 (3.4%) patients had IO complications. During laparoscopic phase, there were 41 vascular events (most injured vessel: splenic artery) and 12 visceral events (most common – splenic injury). During thoracoscopic phase, there were 19 vascular (most common: aorta) and 18 visceral injuries (most common: lung). The Authors reported overall conversion rate of 49% and a 90- day mortality rate of 9.2%.[16] Similarly, a Dutch group reviewed 2598 patients (48% MIE) and reported 23 splenectomies (0.9%), 10 intestinal damages (0.4%), and seven (0.3%) damages to the trachea. In fact, this study aimed at association of complications with body mass index.[20]

In our series, major overall IO complications were 2.9% (vascular: 0.7%, tracheo-bronchial: 0.7%, pulmonary: 0.7%, and splenic: 0.3%). Compared to the largest series by Söderström et al.[16], which reported vascular injuries in 2%, pulmonary injuries in 3.8%, splenic injuries in 1.7%, and tracheal injuries in 1.7% of cases, our IO complication rates are lower across all categories. Furthermore, while Söderström et al. documented a conversion rate as high as 49% and a 90day mortality of 9.2%, none of our patients required conversion due to IO complications. Secondly, we had two cases (0.7%) of thoracic duct injury which were identified intraoperatively. Global literature reports only postoperative chylothorax which we believe should be due to unnoticed injury of thoracic duct during surgery. Therefore, it becomes extremely important to look for thoracic duct injury and clip it at supradiaphragmatic location and at the site of injury. We did not have any postoperative chylothorax despite IO injuries in two cases.

In cases of vascular injury, the mean estimated blood loss in the European series ranged between 1,240–1,410 ml, whereas our cohort demonstrated a lower mean blood loss of 640 ml. Importantly, there was only one 90day mortality following a bronchial injury in our series, and no intraoperative deaths occurred. These findings suggest that our preparedeness and management strategies were quite effective and at least not inferior to published international benchmarks.

A steep learning curve has been observed for MIE. A large proportion of esophagectomies are still performed at low-volume centers (< 20 cases/ year) which has been linked to a poorer outcome.[21] In addition, esophagectomies are being performed by various surgical specialties including General, Thoracic, Gastrointestinal surgeons and Oncosurgeons. The level of training also varies among these specialties. Since IO disasters are uncommon, it can be assumed that many surgeons lack familiarity with the range of possible complications.[11] Our study reports different kinds of IO complications, hence it can help draw attention to the most hazardous parts of MIE and increase surgical safety.

There are several limitations to this study, the main being its retrospective nature though the database was maintained prospectively. Another obvious limitation is the inclusion of both transhiatal and McKewon's MIE and in the latter group a good number of patients (n=148; 49%) had undergone a hybrid approach. Nevertheless, in all patients with Hybrid approach, the crucial step of the tumor resection (all had tumors located in thoracic esophagus and GEJ type I in this category) and lymphadenectomy was done thoracoscopically. Only the mobilization of conduit was done by open approach. In Transhiatal MIE as well, we attempted to mobilize up to the level of carina. A prospective study of pure MIE would provide more reliable data on incidence and correlation with outcomes. Another limitation seems to be the fact that crucial steps of all surgeries were performed by the same surgeon (corresponding author of the article), who

might have crossed his learning curve in a span of 24 years and hence, lesser IO disasters. Moreover, all the complications were managed by minimally approach with zero conversion rate and no on-table mortality. The principal strength of this study is the lack of literature on this topic so far from Nepal. We had earlier published our experience and results of MIE, but we had not analyzed specifically IO complications.[22,23] We identified a wide range of different types of complications, and this was not limited by the retrospective nature of the study. All patients experiencing IO complication were discharged in satisfactory status except the single mortality who had invasion of left main bronchus by tumor. This patient developed right sided lobar pneumonia and later progressive septicemia. The main lesson that we learnt from our complications is a precise dissection, early recognition and preparedness with a prompt action in case of IO disasters.

This study sheds new light on different IO complications and hazardous situations encountered during MIE. Even though overall incidence appears low, mortality, especially from intrathoracic vascular injuries, can be quite significant.

Conclusion

MIE is a challenging surgery with high morbidity rates and any intra operative injury to the adjacent vital structures may prove catastrophic to the patient. Though overall incidence is low, our outcome analysis might serve as a reference to compare and evaluate performance in Nepalese context.

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