REVIEW

Anesthesia and Perioperative Medicine

Predicting and Preventing Postoperative Pulmonary Complications after Esophagectomy in the Era of Enhanced Recovery after Surgery

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Abstract

Postoperative pulmonary complications (PPC), anastomotic leakage and cardiac complications were the most common complications after planned esophagectomy, with an incidence of 30%, 19% and 13% respectively. However, 5-year survival in early stage esophageal cancer patients with or without postoperative pulmonary complications was 40% and 65%. In the era of enhanced recovery after surgery (ERAS), PPC after esophagectomy has dropped greatly owing to more proven evidence including perioperative goal-guided hemodynamic therapy, intraoperative protective ventilation, effective multimodal pain relief, minimally invasive esophagectomy compared with several years ago.

Keywords: *postoperative pulmonary complications; esophagectomy; enhanced recovery after surgery*

Why predicting pulmonary complications after esophagectomy is important?

Postoperative complications after curative resection after esophageal cancer were reported to be 26%-70%, and postoperative complications were associated with increased perioperative mortality and decreased 5-year survival [1,2]. Postoperative pulmonary complications (PPC), anastomotic leakage and cardiac complications were the most common complications after planned esophagectomy, with an incidence of 30%,19% and 13% respectively [2]. With the development of surgical techniques, minimally invasive esophagectomy (MIE) has been recommended as a standard approach in oncological esophageal surgery [3]. In a recent meta-analysis which enrolled 30850 patients, the occurrence of arrhythmia (OR=0.69) and PPC (OR=0.45) was significantly lower in in MIE group compared with open esophagectomy group [4]. However, 5-year survival in early stage esophageal cancer patients with or without postoperative pulmonary complications was 40% and 65% (P<0.001)[1].

Neoadjuvant therapy has improved survival in resectable esophageal cancer patients [5,6]. For unsectable esophageal lesions, although definitive chemoradiotherapy may offer opportunity of complete response, a large portion of patients had residual or relapsed tumors which may needs salvage esophagectomy. PPC were also risk factors of perioperative mortality and unfavourable 5-yeat survival [7,8]. Hayami et al reported a series of received salvage esophagectomy after definitive chemoradiotherapy [8]. PPC occurred in 23 patients (32.9%), and patients who developed PPC had decreased 5-year survival compared with patients who did not develop (11.7% vs 28.5%).

Common risk factors and preventive measures of pulmonary complications after esophagectomy

The occurrence of PPC was multifactorial including pre-, intra- and postoperative parameters. Preoperative factors, such as age, the status of tumor, nutrition status, pulmonary function, preoperative therapies, comorbidities are associated with increased risk of postoperative pulmonary complications [9]. In addition, positive fluid balance, duration of one-lung ventilation are all risk factors of PPC. In a retrospective study, Xing et al reported that patients who had positive fluid balance of 3.8 L were associated with higher incidence of PPC compared who had positive fluid balance of 2.6 L on postoperative day 1 after esophagectomy [10]. In another retrospective study, Lai et al found that in patients who underwent McKeown esophagectomy, there is significant difference in the incidence of PPC between patients who had one-lung ventilation over150 minutes or not(18.0% vs 7.3%, $p < 0.001$) [11]. Therefore, measures aiming at modifiable factors may decrease rate of PPC and improve short-term and long-term prognosis.

Poor nutrition leads to expiratory muscle weakness, which increase the risk of PPC. In a study involving 75 patients who underwent upper abdominal surgery, Lunardi found that expiratory muscle weakness was correlated with body mass index (BMI). Thirty patients who presented with expiratory muscle weakness with an incidence of 52%. Patients who had expiratory muscle weakness had a higher incidence of PPC compared with controls (31% vs 11%)[12]. Although intensive nutritional support decrease the incidence of postoperative complications after esophagectomy [13], there is no evidence supporting the role of nutritional support in decreasing the rate of PPC after esophagectomy.

Excessive fluid volume may lead to increased pulmonary capillary hydrostatic pressure, which resulted in increasing capillary permeability and acute lung injury developed[14]. However, a restrictive fluid regimen was associated with a higher rate of acute kidney injury[15]. Therefore, it is reasonable to optimize the fluid status to prevent organ dysfunction and enhance postoperative recovery. In a recently network meta-analysis involving 101 randomized controlled trials, Zhao demonstrated that goal-directed hemodynamic therapies focus on intravascular volume, stroke volume, and cardiac output optimization are most effective measures for mortality and acute kidney reduction[16]. However, there is no data on the association between goal-directed hemodynamic therapies and PPC in their study. In a randomized controlled trial, perioperative, cardiac output–guided hemodynamic therapy was not associated with reduction of acute respiratory distress syndrome of pneumonia compared with controls in patients who underwent major gastrointestinal surgery [17]. In another randomized controlled trial, there are no significant differences in pneumonia or pulmonary edema between restrictive fluid regimen and liberal fluid regimen. However, there is trend that median duration of mechanical ventilation in the restrictive fluid regimen group [15]. In their study, restrictive fluid regimen refers to net zero fluid balance. Therefore, more evidence is needed to clarify the role of perioperative goal-guided hemodynamic therapy or restrictive fluid regimen in the reduction of PPC after esophagectomy.

Use of low tidal volumes reduced mortality in patients with acute respiratory distress syndrome by prevention of hyperinflammation[18]. Futier et al conducted a multicenter study which compared intraoperative low-tidal-volume ventilation or not in abdominal surgery [19]. The rate of PPC defined as acute respiratory failure in need of noninvasive ventilation or intubation was significantly lower in low-tidal-volume ventilation group than that in controls (5% vs 17%). In a recent review involving 19 randomized controlled trials, intraoperative protective ventilation during surgery was associated with reduction of PPC [20]. In Shen et al's randomized controlled trial, the incidence of PPC was 9.4%, which was significantly lower than 27.0% in the controls [21].

Kehlet et al reported that effective pain relief integrated with an accelerated rehabilitation programme accelerated postoperative recovery after open colonic surgery [22]. After then, the concept of enhanced recovery after surgery (ERAS) was established. In 2010, the ERAS society was founded in Sweden and issued several guidelines including guidelines for perioperative care in esophagectomy [23]. Multimodal non-opioid analgesia including thoracic epidural anesthesia and/or paravertebral block was recommended as opiate may leads to side effects including sedation, nausea and vomiting, delirium and gut dysfunction [23]. There is no significant difference in PPC between thoracic epidural anesthesia and paravertebral block after thoracotomy in a recent review [24]. Appropriate analgesia can reduce the stress response, restore breath function, and facilitate early mobilization. And early mobilization reduces the incidence of PPC after esophagectomy. Hanada retrospectively reviewed 118 patients who underwent minimally invasive esophagectomy (MIE) and found that early mobilization was negatively correlated with the incidence of residual of postoperative pulmonary atelectasis[25].

Since the first study published in 2012, MIE has been gradually accepted as an alternative approach for esophagectomy[26]. Several meta-analyses have been published and concluded that MIE was associated with reduced PPC compared with open esophagectomy [4, 27-29]. In the 2019 ERAS recommendation, MIE was regarded as an acceptable access as open esophagectomy and MIE seems to be associated with reduced rate of pulmonary infections without any significant disadvantages [23].

Although preoperative corticosteroid administration was associated with a relative risk reduction of at least 23% to 54% of postoperative morbidity following esophagectomy in an early meta-analysis involving 8 clinical trials [30], there was inconsistency between 2019 ERAS recommendation and Society for Translational Medicine Expert Consensus[23,31]. In the 2019 ERAS recommendation, preoperative corticosteroid administration was not mentioned.

Decreased forced expiratory volume in 1 second (FEV1%) and decreased diffusion capacity of the lung for carbon monoxide (DLCO%) have long been considered as risk factors in predicting major PPC after open esophagectomy [32]. However, FEV1% was not risk a factor of PPC in a cohort of 184 patients after MIE [33].

Conclusion

In the era of ERAS, PPC after esophagectomy has dropped greatly owing to more proven evidence including perioperative goal-guided hemodynamic therapy, intraoperative protective ventilation, effective multimodal pain relief, minimally invasive esophagectomy compared with several years ago [34]. With the development of guidelines of ERSA for perioperative care in esophagectomy, the rate of PPC after esophagectomy may decline further.

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