Editorial Commentary

Minimally invasive esophagectomy—behind patient-centered learning curves

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A critical component of the management of patients with localized and locoregional esophageal cancer is surgical resection. The morbidity and mortality associated with open esophagectomy has led to the adoption of minimally invasive approaches (1). As a result, a growing body of research has demonstrated that minimally invasive esophagectomy (MIE) is associated with lower early perioperative morbidity [e.g., pulmonary insufficiency and infection (2)] and mortality (3) than historically reported after open esophagectomy. Importantly, MIE is also associated with similar oncologic outcomes, regardless of stage of disease (4).

A minimally invasive approach to esophagectomy, however, remains a technically complex operation with additional unique challenges in pre- and postoperative care (5). The adoption of any new procedure or surgical technique is associated with a learning curve, the period immediately after the introduction of a new procedure (6), and many have described a steep and long learning curve for MIE (7-10). The outcomes in many of these primarily retrospective, single-center studies are intraoperative and postoperative endpoints, such as operative time, blood loss, quality of lymphadenectomy, or hospital length of stay. In a recently published study in *Annals of Surgery*, van Workum *et al.* describe a learning curve for minimally invasive Ivor Lewis esophagectomy in a retrospective, multicenter center study, where the primary endpoint was anastomotic leakage (11). The findings reported in this study extend from those of prior research by describing favorable early postoperative outcomes for over 600 patients after MIE. Furthermore, the results underscore the challenges in quantifying the factors associated with the MIE learning curve, as well as the importance of measuring learning curve associated morbidity.

The factors influencing the implementation of MIE, in terms of optimizing patient outcomes, are multifactorial. Perhaps most obvious is prior thoracic surgeon experience. Although many consider the learning curve as a phase for primarily refining surgical technique, there are significant components contributing to the learning curve for MIE that occur in pre-, intra-, and postoperative phases. Before entering the operating theater for MIE, patient evaluation and coordination of a multidisciplinary care team affects patient outcomes (12). Doing so uncovers patient- and disease-specific considerations that may affect the intraoperative learning curve for MIE, such as body mass index or neoadjuvant therapy.

As van Workum *et al.*'s results suggested, prior thoracic surgical experience (e.g., specialty training, number of prior open Ivor Lewis esophagectomies, number of prior totally MIE with cervical anastomosis, etc.) were important considerations. While each approach (e.g., open versus laparoscopic; intrathoracic versus cervical anastomosis) can be considered distinct procedures, common principles overlap: intimate knowledge of the thoracic and foregut anatomy and common anatomical variants; safe mobilization of the stomach and creation of the gastric conduit;

esophageal resection and complete lymphadenectomy; and fashioning a low-tension, well-vascularized esophagogastric anastomosis. Without accounting for prior surgeon experience, it is difficult to describe a true learning curve for MIE among a group of thoracic surgeons with varying levels of experience.

Beyond the technical ability of a thoracic surgeon, it is well described that the training of the entire surgical team and operating theater culture impact patient safety and outcomes (13). Further research is needed to determine how these factors contribute to a patient-centered learning curve of any new operation, especially high-acuity, complex procedures like MIE. For example, preoperative coordination and intraoperative communication with anesthesiologists experienced with techniques unique to thoracic surgery (e.g., lung isolation with double-lumen endotracheal intubation with intraoperative reposition) for initial consecutive cases is likely beneficial (14,15). The ability and complementary efforts of the first-assistant surgeon also is important, and teaching hospitals with rotating residents and fellows likely affect the length the learning curve. Interestingly, in practices with multiple thoracic surgeons performing MIE, the learning curve for the non-surgical team may be shorter than that of any individual thoracic surgeon, as the remainder of the team accumulate learning across the cases of all surgeons performing MIE.

Outside of the operating theater, the perioperative patient management after MIE impacts patient outcomes. At our institution, the increasing numbers of completed MIEs naturally led to the development of standardized perioperative protocols by a multidisciplinary team (5,7) including the surgeon, anesthesiologist, surgical critical care team, radiologists, and nutritionists. Similar to others, our protocol includes routine use of regional analgesia, immediate admission to a monitored inpatient ward or intensive care unit, and postoperative contrast swallow study. Favorable patient outcomes after the implementation of MIE must be appropriately attributed to these advancements in the postoperative phase of care, as should the patient-centered learning curve.

It is challenging, therefore, to account for each of these factors—surgeon experience, operating teams' culture, and postoperative multidisciplinary care—when determining the true learning curve for MIE. Among experienced, high-volume thoracic surgical centers already facile at the MIE with cervical anastomosis, the learning curve for minimally invasive Ivor Lewis esophagectomy perhaps more specifically describes the learning curve of a minimally invasive intrathoracic, rather than cervical, esophagogastric anastomoses. On the contrary, among junior thoracic surgeons approaching the MIE as their index technique for esophageal resection, how do surgeons interpret what specifically is being described by the learning curve (e.g., patient selection, surgical technique, postoperative care, etc.)? By determining what is hidden within the learning curve for MIE will allow thoracic surgeons to not only develop metrics to measure proficiency at certain critical portions of the MIE, but also best practices for the multidisciplinary care team during all phases of surgical care.

Although many have described various lengths of learning curves for MIE, as well as proposed ways to harness these data to improve patient outcomes, few have attempted to describe the burden of the learning curve, in terms of associated patient morbidity. van Workum *et al.* should be commended for studying the adoption of MIE using this innovative approach. The learning curve associated anastomotic leakage as described in this study represents the number of patients who experienced an anastomotic leakage that may not have occurred had they undergone surgery after the learning curve. From both a methodologic and clinical perspective, this approach to uncovering the learning curve for MIE has several advantages. Learning-curve associated anastomotic leakage provides a patient-centered outcome that quantifies the burden upon patients that can be attributed to the learning phase. Additionally, metrics frequently used in learning curve analyses for MIE, such as operative time and estimated blood loss, are often discussed as surrogates for learning. While these intraoperative metrics may be associated with postoperative patient outcomes, further research is needed to truly assess their accuracy in measuring surgeon and surgical care-team learning and proficiency. Subsequent research will take patient-centered learning curves even further, beyond operative time, blood loss, and even patient morbidity. Five-year oncologic and survival data will become additional endpoints for understanding the impact of various learning curves for MIE. Furthermore, studying learning curves targeted to patient quality of life data and patient-reported outcome measures is paramount. This is particularly true after MIE, where the impact of not only the surgery, but also neoadjuvant and adjuvant treatment has been shown to have notable effects on patient quality of life.

There is indeed a vast amount of clinically actionable data described by a learning curve for MIE. Furthermore, there remains a great opportunity for thoracic surgeons to explore how more than the refinement of surgical technique affects the learning curve. From accounting for prior thoracic surgical experience, to targeting patient-centered outcomes and quality of life metrics rather than perioperative surrogates for true learning, future research will underscore and uncover the factors affecting the successful implementation of MIE and other complex, high-acuity thoracic operations.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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