Ontario
Cancer Care Ontario
Action Cancer Ontario

Evidence-Based Series 17-1 Version 2

A Quality Initiative of the
Program in Evidence-Based Care (PEBC), Cancer Care Ontario (CCO)

Thoracic Surgical Oncology Standards

The Expert Panel on Thoracic Surgical Oncology

A Special Project of the Surgical Oncology Program, Cancer Care Ontario and
The Program in Evidence-Based Care, Cancer Care Ontario
Developed by the Expert Panel on Thoracic Surgical Oncology

An assessment conducted in January 2024 deferred the review of Evidence-based Series (EBS) 17-1 Version 2. This means that the document remains current until it is assessed again next year. The PEBC has a formal and standardized process to ensure the currency of each document (PEBC Assessment & Review Protocol)
Edits were made with respect to esophagectomy surgical volumes in August 2021.

EBS 17-1v2 is comprised of 5 sections. You can access the summary and full report here:
https://www.cancercareontario.ca/en/guidelines-advice/types-of-cancer/2171

Section 1: Standards (ENDORSED)
Section 2: *Systematic Review (available from* ccopgi@mcmaster.ca).
Section 3: Guideline Development and External Review - Methods and Results
Section 4: Document Review Summary and Tool
Section 5: Review of Esophageal Cancer Surgery Recommendations

Release Date: March 4, 2015

For information about the PEBC and the most current version of all reports,
please visit the CCO website at http://www.cancercare.on.ca/
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Guideline Report History

GUIDELINE VERSION	SYSTEMATIC REVIEW		PUBLICATIONS	NOTES and KEY CHANGES
	Search Dates	Data		
Original September 2005	1990 through December 2004	Full Report	Peer review publication Web publication	NA
Current Version 2 March 2015	2004 to December 23, 2013	New data found in Section 4: Document Review Summary and Review Tool	Updated web publication	2005 recommendations are **ENDORSED**
Current Version 2 March 2015	2013 to Feb 2020	New data found in Section 5: Review of Esophageal Cancer Surgery Recommendations	Updated web publication	Changes and new qualifying statement to thoracic surgery volume

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Evidence-Based Series #17-1 Version 2: Section 1

Thoracic Surgical Oncology Standards

S. Sundaresan, B. Langer, T. Oliver, F. Schwartz, M. Brouwers, H. Stern, and the Expert Panel on Thoracic Surgical Oncology

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Developed by the Expert Panel on Thoracic Surgical Oncology.

Report Date: September 9, 2005

These guideline recommendations have been ENDORSED, which means that the recommendations are still current and relevant for decision making. Please see Section 4: Document Review Summary and Tool for a summary of updated evidence published between 2005 and 2013, and for details on how this Clinical Practice Guideline was ENDORSED.
Edits were made with respect to esophagectomy surgical volumes in August 2021; See Section 5.

Question
What is the optimum organization for the delivery of cancer-related thoracic surgery in Ontario?

Scope of Standards
The following standards, developed by the Expert Panel on Thoracic Surgical Oncology, apply to thoracic surgical oncology and include the full spectrum of multi-disciplinary assessment and treatment.

Surgeon Criteria
General characteristics for surgeons undertaking the management of patients with thoracic cancer are as follows:

- Knowledgeable about thoracic cancer biology, behaviour, and natural history.
- Well informed of appropriate investigation techniques, multidisciplinary treatment options as well as postoperative management and the continuum of care.
- Skilled in modern techniques of surgery of the thoracic region.
- Experienced in the management of patients with thoracic diseases, specifically, the management of their complications, early and late.

- Committed to providing excellence in care to patients with thoracic diseases, specifically cancer patients, and to advancing knowledge in the field to improve patient outcomes.
- Committed to participating as a member of a multidisciplinary oncology team or to consulting with such teams.
- Committed to participating in Cancer Care Ontario initiatives, particularly those of the Surgical Oncology Program, and/or in the Program in Evidence-Based Care through membership in working groups, standing groups, or as active participants in external review and consultation processes.

Training

- Surgeons should have completed formal training in programs such as the Royal College of Physicians and Surgeons of Canada (RCPSC) programs in thoracic surgery, cardiothoracic surgery or cardiovascular and thoracic surgery, or the American Board of Thoracic Surgery or other equivalent training recognized in Canada, and be certified and licensed to practice thoracic surgery in Canada.
- Surgeons should maintain expertise and competence through ongoing education in available Continuing Professional Development (CPD) programs, such as the Maintenance of Certification (MOC) program of the RCPSC or others.

Practice Setting

- Level 1 Tertiary care regional thoracic centres should be equipped to manage the full range of thoracic surgical care, as well as acting as the primary source to manage the most complex cases. To facilitate this goal, there should ideally be at least three thoracic surgeons on staff to provide intraoperative assistance and postoperative care, and weekend, holiday and emergency coverage.
  - This number of surgeons is needed to provide the capacity for tertiary clinical care in addition to the other requirements and responsibilities of a multidisciplinary cancer care facility, including teaching, research, quality improvement, and program advancement.
  - A team approach is understood to improve the quality of surgery in complex cases and the judgment required to manage complications.
- In some regions of the province, the population may not support a Level 1 thoracic centre. In these regions, a Level 2, or secondary care unit, may be established to serve the basic thoracic surgery needs of the population.
  - Level 2 centres should have:
    - A minimum of one thoracic surgeon who performs routine thoracic procedures.
    - A formalized relationship with a Level 1 tertiary centre to which the thoracic surgeon may refer complex thoracic cases (e.g., tracheal resections, esophageal cancers, major chest wall resections, etc.).
    - Arrangements with surgical colleagues in those centres to provide support in the event of the thoracic surgeon's absence.
- Level 2 centres performing esophagectomies should meet the same criteria for human resources, hospital resources, and practice setting recommendations (e.g., three thoracic surgeons and a dedicated surgical service) as a Level 1 centre. The volume of pulmonary resections would remain at 50 cases per year. The volume of esophagectomies should be 15 cases per year.
- Hospitals not meeting Level 1 or 2 thoracic surgery criteria should establish formal relationships with a Level 1 or Level 2 centre to facilitate consultation, appropriate management and referral of patients with thoracic malignancies. For those hospitals where

the geographic location, patient volume or population catchments do not support Level 1 or 2 status, the basic thoracic service needs may still be provided in that area through formal relationships with Level 1 and 2 centres. Guided by the expertise of these centres, much of the initial/pre-operative evaluation can be conducted at that hospital itself. The surgical care would require transferring the patient to the Level 1 or 2 Thoracic surgery unit. However, upon completion of the surgery, the patients can return to the originating centre for ongoing care and follow-up as deemed appropriate and necessary by the multidisciplinary group at the Level 1 or 2 centre.

Volume of Thoracic Surgery

- The practice setting should have a sufficient volume of thoracic surgery to maintain the skills of surgeons in both complex cancer surgery and thoracic surgery.
- Surgical volumes of a minimum of 150 pulmonary resections per unit per year should be considered targets for Level 1 centres.
- Surgical volumes of a minimum of 50 pulmonary resections per unit per year should be considered targets for Level 2 centres.
- Surgical volumes of a minimum of 15 esophagectomy cases per unit per year should be considered targets for either a Level 1 or Level 2 centre.
- These volumes were considered reasonable by the expert panel in light of the current distribution of thoracic surgery in the province, but it is recommended that these numbers be revisited as more data becomes available.
- The panel recognized that some regions may not have the population and cases to support the recommended target volumes but could meet them as the predicted increase in cancer cases occurs.

Qualifying Statements –

Updated in August 2021:

Centres offering cancer-related esophagectomy should meet the institutional requirements of a Level 1 centre, including three thoracic surgeons and a minimum 15 esophageal resections per year. See Section 5 for details.

Added in the Update and Endorsement in March, 2015

The original 2005 recommendations on surgical volumes were modified in 2015 by the Expert Panel. The words 'in the range' and 'anatomic' were deleted. See Section 4, page 16 for additional information.

The original and the revisions to the surgical volume target recommendations are based on the expert opinion of the guideline panels. In the updated literature review (to December 2013) no new data were identified to inform the volume target recommendations.

Hospital Criteria

Important characteristics of the institution in which major thoracic cancer surgery would take place are:

- Commitment to high-quality multidisciplinary thoracic cancer care.
- Commitment to providing or participating in an organizational structure to manage patients with these cancers through all phases of their care.
- Commitment to participate in activities that advance CCO's Provincial Cancer Plan (2004).
- Formal working relationship or association with a regional cancer centre, if a thoracic surgery unit is not located at the cancer centre.

Physical Resources and Collaborating Services

The following physical resources and collaborating services are considered to be reasonable criteria which Level 1 and 2 hospitals providing thoracic cancer surgery should be expected to meet in providing comprehensive acute care:

- Operating Room that is available 24 hours per day, 7 days per week (24/7), with video capacity for bronchial and esophageal scopes, Video Assisted Thoracic Surgery (VATS) and laparoscopy, intra-operative fluoroscopy capacity, and frozen section available 24/7 for emergencies.
- An interventional radiology suite that has the capacity for needle biopsy of lung and chest masses and drainage of loculated pleural collections and that is available 24/7 for emergencies, either onsite or at an on-call hospital. The capacity for embolization therapy for massive hemoptysis or prior to massive chest wall resections is essential for Level 1 centres.
- Full spectrum of radiological imaging, including X-ray and immediate portable X-ray access 24/7 for emergencies, esophageal contrast studies, CT, MRI, ultrasound, nuclear medicine and vascular imaging.
- For Level 1 units – a dedicated thoracic surgical service with consolidated beds to ensure an appropriate level of nursing, physiotherapy and respiratory therapy expertise.
- Specialized nursing care, including mechanical ventilation and invasive monitoring in a combination of ICU and step-down beds sufficient to support the volume of patients treated.
- Affiliation with a regional cancer centre, with access to radiation therapy equipment and consultation from medical and radiation oncologists.
- Ambulatory endoscopy facility with access to surgeons, pulmonologists and gastroenterologists.
- On-site lab for pulmonary function tests (PFT), cardiac diagnostic assessment services, including echocardiography and nuclear imaging.
- On-site rapid response laboratory (i.e., biochemistry, hematology, transfusion and microbiology) services sufficient to support operating room, ICU, step-down and ward requirements 24/7.
- On-site or rapid access pathology and cytology services sufficient to support operating room, endoscopy and ambulatory services.

Human Resources

Human Resources should include:

- Thoracic surgeons.
- Anesthesiologists skilled in thoracic anesthesia techniques.
- Other medical specialists including gastroenterologists, pulmonary medicine specialists, intensivists, a thoracic pathologist and a radiologist with a subspecialty interest in diagnostic and interventional procedures in the chest.
- Allied professionals, including dedicated nurses; chest physiotherapists accessible 7 days a week; respiratory therapists available 24/7; dietary/nutritional, home care, social work, and pharmacy support; and access to a palliative care team.
- Formalized partnerships and access to oncology specialists including medical oncologists and radiation oncologists.
    - Access to other consulting specialties as needed, such as infectious disease, cardiology and neurology specialists.

Organizational Criteria

- The successful management of patients with thoracic problems, particularly those with thoracic malignancies, by involving a multidisciplinary team approach with the use of standard diagnostic and treatment protocols and the involvement of a variety of surgical and non-surgical specialists.
- For Level 1 units - a designated thoracic unit with identified leadership and accountability.
- A system of regular review of multidisciplinary patient management (e.g. multidisciplinary clinics, clinical rounds, educational rounds, morbidity and mortality review, and formal ongoing outcome measurements and quality assurance) is essential for the achievement of optimal patient outcomes.
- Participation in regional and provincial integrated networks of care as outlined in the CCO Provincial Cancer Plan (2004) to facilitate patient access, consultation, referral, quality improvement and continuing professional development.
- Infrastructure support for participation, and the participation, of patients in clinical research in thoracic care, both in local and national studies.

Development of the Standards Document

Evidence on thoracic cancer surgery was gathered through a systematic search of the literature and a scan of documents from organizations concerned with thoracic surgery quality practice. Evidence was reviewed by members of the Expert Panel on Thoracic Cancer Surgical Oncology (see Appendix 1, Section 3) investigating the delivery of cancer-related thoracic surgery in Ontario.

The panel included thoracic surgeons, general surgeons, a medical oncologist, a radiation oncologist, social and behavioural scientists, a hospital Chief Executive Officer, a Cancer Care Ontario Regional Vice President, pathologists, radiologists and methodologists, and representatives from the Canadian Association of Thoracic Surgeons and the Ontario Association of General Surgeons, with representation from across the province.

The standards were developed using a combination of evidence-based analysis, existing recommendations from other jurisdictions, and incorporated expert opinion based on experience and consensus. The panel analyzed data on the current distribution of thoracic cancer surgery across Ontario to inform the process of developing volume standards for Ontario. The standards were developed to accommodate long-range needs and take into account the projected increase in thoracic cancer surgery needs over the next decade due to a growing and aging population.

Related Guidance Documents

This inventory of related guidance has been updated to include documents published up to March 2015. These complementary guidance resources provide additional recommendations for the care of patients with lung cancer.

- Guidelines for the care of lung cancer patients have been developed by the Lung Cancer Disease Site Group (DSG) and can be accessed at this webpage: https://www.cancercare.on.ca/cms/One.aspx?portalId=1377&pageId=10286

- PEBC EBS#7-20 Version 2: *18-Fluorodeoxyglucose Positron Emission Tomography in the Diagnosis and Staging of Lung Cancer* (available at: https://www.cancercare.on.ca/common/pages/UserFile.aspx?fileId=34341)

- PEBC EBS#7-18: *Positron Emission Tomography in Radiation Treatment Planning for Lung Cancer* (available at: https://www.cancercare.on.ca/common/pages/UserFile.aspx?fileId=86361)

- PEBC EBS#7-14 Version 2: *Surgical Management of Malignant Pleural Mesothelioma* (available at: https://www.cancercare.on.ca/common/pages/UserFile.aspx?fileId=34334)

- PEBC Special Report: *Multidisciplinary Cancer Conference Standards* (available at: https://www.cancercare.on.ca/common/pages/UserFile.aspx?fileId=14318)

- PEBC EBS # 15-10: *Screening high risk populations for lung cancer* (available at: https://www.cancercare.on.ca/common/pages/UserFile.aspx?fileId=287881)

- PEBC EBS #17-6: *Invasive Mediastinal Staging of Non-Small Cell Lung Cancer* (available at: https://www.cancercare.on.ca/common/pages/UserFile.aspx?fileId=83787)

- PEBC EBS #26-3: *Follow-up and surveillance of curatively treated lung cancer patients* (available at: https://www.cancercare.on.ca/common/pages/UserFile.aspx?fileId=318621

- PEBC PET Recommendation Report 9: *PET Imaging in Small Cell Lung Cancer* (available at: https://www.cancercare.on.ca/common/pages/UserFile.aspx?fileId=43155)

- PEBC ES#22-2-7: *Best practices for pathology secondary review: Lung Cancer* (available at: https://www.cancercare.on.ca/common/pages/UserFile.aspx?fileId=311334)

- PEBC ES#25-1-1: *Fine Needle Aspiration Biopsy versus Core Needle Biopsy in the Diagnosis of Lung Cancer* (available at: https://www.cancercare.on.ca/common/pages/UserFile.aspx?fileId=254183)

- CCO Disease Pathway Management Secretariat: *Lung Diagnosis Pathway* (available at: https://www.cancercare.on.ca/common/pages/UserFile.aspx?fileId=298429)

- CCO Disease Pathway Management Secretariat: *Non-Small Cell Lung Cancer Treatment Pathway* (available at: https://www.cancercare.on.ca/common/pages/UserFile.aspx?fileId=298431)

- CCO Disease Pathway Management Secretariat: *Small Cell Lung Cancer Treatment Pathway* (available at: https://www.cancercare.on.ca/common/pages/UserFile.aspx?fileId=298427)

- CCO Disease Pathway Management Secretariat: *Esophageal Cancer Treatment Pathway* (available at: https://www.cancercareontario.ca/sites/ccocancercare/files/assets/EsophagealTreatmentPathway-2019-05.pdf

- CCO Cancer Imaging Guidance L-1 Version 1: *Lung Cancer Imaging Guidelines: Integration with the Lung Cancer Diagnosis and Staging Clinical Pathway*. (available at: https://www.cancercare.on.ca/common/pages/UserFile.aspx?fileId=295561)

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Evidence-Based Series #17-1 Version 2: Section 2

Thoracic Surgical Oncology Standards: A Systematic Review

S. Sundaresan, B. Langer, T. Oliver, F. Schwartz, M. Brouwers, H. Stern, and the Expert Panel on Thoracic Surgical Oncology

A Special Project of the Surgical Oncology Program, Cancer Care Ontario and
The Program in Evidence-Based Care, Cancer Care Ontario.
Developed by the Expert Panel on Thoracic Surgical Oncology.

Report Date: September 9, 2005

The systematic review that forms the evidentiary base for this evidence-based series is published in *The Annals of Thoracic Surgery* at http://ats.ctsnetjournals.org/.

A pdf version of *The Annals of Thoracic Surgery* publication is available separately on the CCO Web site at **Thoracic Standards Systematic Review**, with the understanding that the pdf version has been:

> "Reprinted from The Annals of Thoracic Surgery, Vol 84, Sundaresan S, Langer B, Oliver T, Schwartz F, Brouwers M, Stern H; Expert Panel on Thoracic Surgical Oncology. Standards for thoracic surgical oncology in a single-payer healthcare system. Pages No.: 693-701, Copyright 2007, with permission from The Society of Thoracic Surgeons. All rights reserved."

Section 2: A Systematic Review can be obtained by contacting the PEBC office at ccopgi@mcmaster.ca.

For further information about this series, please contact:

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Evidence-Based Series #17-1 Version 2: Section 3

Thoracic Surgical Oncology Standards: Guideline Development and External Review - Methods and Results

S. Sundaresan, B Langer, T Oliver, F Schwartz, M Brouwers, H Stern
and the Expert Panel on Thoracic Surgical Oncology

A Special Project of the
Surgical Oncology Program, Cancer Care Ontario and
The Program in Evidence-Based Care, Cancer Care Ontario.
Developed by the Expert Panel on Thoracic Surgical Oncology.

Report Date: September 9, 2005

THE SURGICAL ONCOLOGY PROGRAM AND THE PROGRAM IN EVIDENCE-BASED CARE COLLABORATION

The Surgical Oncology Program (SOP) and the Program in Evidence-based Care (PEBC) are initiatives of Cancer Care Ontario (CCO). The mandate of the SOP is to improve the delivery of cancer surgery in Ontario through initiatives designed to increase access to care, improve the quality of care, support the recruitment and retention of cancer surgeons, support knowledge transfer and evidence-based practice and foster research and innovation. The mandate of the PEBC is to improve the lives of Ontarians affected by cancer, through the development, dissemination, implementation, and evaluation of evidence-based products designed to facilitate clinical, planning, and policy decisions about cancer care.

The PEBC is best known for producing high-quality evidence-based practice guideline reports, using the methods of the Practice Guidelines Development Cycle (1,2). A typical PEBC report consists of the comprehensive systematic review of the clinical evidence on a specific cancer-related topic, the interpretation of and consensus agreement on that evidence, the resulting clinical recommendations, and the results of an external review by Ontario clinicians for whom the topic is relevant. The PEBC has a formal standardized process to ensure the timeliness of each clinical practice guideline report, conducting routine periodic reviews and evaluations of the scientific literature and, where appropriate, integrating that literature with the original practice guideline report information.

The SOP and the PEBC have worked collaboratively on a number of occasions to develop evidence-based materials relevant to the surgical community in Ontario, which includes the creation of thoracic surgical oncology standards.

As part of its quality improvement mandate, the SOP convenes expert panels for the selection of quality indicators and the development of clinical guidelines and organizational standards. The panels are comprised of surgeons, other clinicians and methodologists and are

established on an as-needed basis for specific quality initiatives, such as the development of the thoracic surgical oncology standards.

In this instance, the SOP coordinated the development of the Expert Panel on Thoracic Surgical Oncology and the PEBC contributed methodological expertise. The PEBC process and report format has been adapted for the thoracic standards document.

The Evidence-Based Series

This Evidence-Based Series is comprised of the following three sections:

- ***Section 1: Standards***
  This section contains the standards derived by the Expert Panel on Thoracic Surgical Oncology Standards through systematic review, an environmental scan, interpretation of the clinical and scientific literature and consensus process, as well as through a formalized external review by Ontario practitioners and administrators.
- ***Section 2: Systematic Review***
  This section presents the comprehensive systematic review of the clinical and scientific research, the environmental scan and panel discussion on the topic and the conclusions drawn by the Expert Panel on Thoracic Surgical Oncology Standards.
- ***Section 3: Methodology of the Guideline Development and External Review Process***
  This section summarizes the standards development process and the results of the formal external review by Ontario practitioners and administrators of the draft version of the thoracic surgical oncology standards and systematic review.

DEVELOPMENT OF THE EVIDENCED-BASED SERIES

Developing the Draft Systematic Review and Standards

This Evidence-Based Series was developed by the Expert Panel on Thoracic Surgical Oncology Standards. The series is a convenient and up-to-date source of the best available evidence developed through systematic review, evidence synthesis, and input from practitioners and administrators in Ontario. Section 2 contains the systematic review of the evidence on outcomes related to the optimum delivery of cancer-related thoracic surgery. The draft recommendations derived from the interpretation of that evidence by members of the expert panel are detailed in Section 1. Sections 1 and 2, along with Section 3, are circulated to Ontario practitioners and administrators for their feedback. Section 3 presents the feedback process results, any changes made to the draft document.

Practitioner Feedback

Practitioner and administrator feedback was obtained through a mailed survey of 132 practitioners and administrators in Ontario (primarily surgeons, thoracic surgeons, and hospital administration). The survey consisted of items evaluating the methods, results, and interpretive summary used to inform the draft standards and whether the draft standards should be approved as a provincial guidance document.

Sixty-three responses were received out of the 132 surveys sent (48% response rate). Of the 63 respondents, 56 completed the questionnaires and 42 provided written comments.

The items that 80% or more respondents agreed to were the rationale and need for thoracic surgery standards in Ontario, the methodology used, the interpretation of the data in the systematic review, the clarity of the standards report, and the perceived comfort level of patients and practitioners if the care outlined in the standards document were offered. Seventy 70% of the respondents agreed with the draft standards as stated, and 75% agreed that the draft standards would produce more benefits than harms.

Roughly half of the respondents agreed that the standards would be suitable and acceptable to the system, would not be too rigid or expensive to apply, but would also require

service re-organization and would be technically challenging. About half agreed that the standards would be supported by a majority of colleagues and that expected patient outcomes would be obvious. In a comparison of the proposed standards to current thoracic surgery practice, approximately 20% of respondents indicated that their centres were already practicing the type of care outlined in the standards document. Roughly half of respondents agreed that the standards would reflect a more effective approach for improving patient outcomes and, when applied, would reflect a more effective use of resources.

In terms of formal approval as a CCO standards document, 56% of respondents agreed that the document should be formally approved, 25% were unsure, and 19% disagreed with formal approval. Approximately half of respondents agreed with the statements that they (55%) or their centre (46%) would be likely to apply the standards if formally approved. The remaining respondents were either unsure, (26% and 15% respectively) or disagreed with the statements (28% and 28% respectively).

The respondents also provided written comments. The major themes emerging from the comments provided by the respondents included:

- support for the document or the process of standardization of thoracic oncology surgery (12 comments in total),
- comments regarding the volume of thoracic surgery being too high, exclusive to some centres, difficult to implement, or not firmly based upon the evidence (6 comments in total).
- comments on the number of thoracic surgeons potentially affecting current level 1 or 2 status, the feasibility of 3 thoracic surgeons per level one centre, and accommodation for smaller academic centres if they can document adequate outcome data (4 comments in total).
- comments that the standards around practitioner certification could include non-certified surgeons with similar training and experience as certified thoracic surgeons, that relatively few level 2 facilities would have a full-time thoracic surgeon, or that the literature supports that volume as a better indicator of outcomes than certification status (3 comments in total).
- comments that financial, organizational or manpower resources would need to be infused into the current system to achieve the standards as stated (11 comments in total).
- comment that the standards around the practice setting the relationship between level 1 and 2 centres was not explicit and that defining and implementing level 2 centres would be challenging, especially for remote populations that were geographic or volume based (7 comments in total).
- general comments included the identification of a recent article, the potential for legal risks for surgeons with a standards document, more representation from thoracic surgeons from proposed level 2 type centres, and a suggested change in the standards document title (4 comments in total).

These points were brought back to the Panel for discussion. While identifying explicit volumes for Level 1 and Level 2 centres have not been the explicit subject of study, these standards reflect the best interpretation of the available evidence. The Panel continues to support these recommendations. The remaining points revolve around the implementation of these standards. These points were brought back to the Panel for discussion. While identifying specific volumes for Level 1 and Level 2 centres have not been the explicit subject of study, these standards reflect the best interpretation of the available evidence. The Panel continues to support these recommendations. The remaining points revolve around the implementation of these standards. While an implementation plan is beyond the scope of the current document, the use of guidelines and standards is fundamental to the success of cancer Care Ontario's quality improvement initiatives. This standards document will provide an

important source of information for regional and provincial planning of thoracic cancer surgery services.

Report Approval Panel

The final version of the Evidence-Based Series was submitted to the Report Approval Panel (RAP) of the PEBC for approval. The RAP approved the document but requested clarity around (i) the complexity of surgeries recommended in the Level 1 and Level 2 centres and (ii) some methodological steps (e.g., details regarding working group role, how consensus was reached, decisions regarding data synthesis and pooling). These details were added to the final document.

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REFERENCES

1. Browman GP, Levine MN, Mohide EA, Hayward RS, Pritchard KI, Gafni A, et al. The practice guidelines development cycle: a conceptual tool for practice guidelines development and implementation. J Clin Oncol. 1995;13:502-12.
2. Browman GP, Newman TE, Mohide EA, Graham ID, Levine MN, Pritchard KI, et al. Progress of clinical oncology guidelines development using the practice guidelines development cycle: the role of practitioner feedback. J Clin Oncol 1998;16:1226-31.

Appendix 1: Expert Panel on Thoracic Surgical Oncology members. (2005)

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Evidence-Based Series #17-1 Version 2: Section 4

Thoracic Surgical Oncology Standards: Guideline Review Summary and Review Tool

S. Sundaresan, A. E. Haynes and the Expert Panel on Thoracic Surgical Oncology

A Special Project of the Surgical Oncology Program, Cancer Care Ontario and
The Program in Evidence-Based Care, Cancer Care Ontario.
Developed by the Expert Panel on Thoracic Surgical Oncology

Review Date: March 4, 2015

The 2005 guideline recommendations are

ENDORSED

This means that the recommendations are still current and relevant for decision making.

OVERVIEW

The original version of this guidance document was released by Cancer Care Ontario's Program in Evidence-Based Care in 2005. In November 22, 2013, this document was assessed in accordance with the PEBC Document Assessment and Review Protocol and was determined to require a review. As part of the review, a PEBC methodologist conducted an updated search of the literature. A clinical expert (SS) reviewed and interpreted the new eligible evidence and proposed the existing recommendations could be endorsed. The Expert Panel on Thoracic Surgical Oncology (the Expert Panel, see Appendix 3) endorsed the recommendations found in Section 1 (Guideline Recommendations) on March 4, 2015.

DOCUMENT ASSESSMENT AND REVIEW RESULTS

Questions Considered

What is the optimum organization for the delivery of cancer-related thoracic surgery in Ontario?

Literature Search and New Evidence

The new search (January 2004 to December 23, 2013) yielded a total of 14 publications of 11 systematic reviews and 99 publications of primary studies—most were retrospective cohort designs. The results of the included systematic reviews and primary studies can be found in the Document Review Tool.

Impact on Guideline and its Recommendations

The evidence supports the existing recommendations; specifically, the identified systematic reviews and meta-analyses provide strong evidence of a volume-outcome relationship, for both hospital and surgeon volume, in thoracic oncology surgery. Both high hospital volume and high surgeon volume are associated with lower 30-day mortality. The evidence shows a weaker link between hospital or surgeon volume and long-term survival. It should be noted that during the development of the 2005 recommendations, there was a lack of evidence for several recommendations; however, some low to moderate quality studies are now available that investigated the relationship between outcome and other variables such as, type of hospital (academic versus community, designated cancer centre versus non-designated cancer centre); type of surgeon (thoracic versus general), and; physical resources and organizational requirements (use of multidisciplinary teams and cancer conferences, and associated health care human resources such as nurses and anaesthesiologists). Although the data on these variables appear to be promising, the relationship to outcome is not as clear as that for the hospital or surgeon volume-outcome relationship.

The Expert Panel agreed that no new recommendations are required and that the 2005 recommendations cover all relevant subject areas identified in the new evidence; therefore, the Expert Panel ENDORSED the 2005 recommendations on thoracic surgical oncology standards.

Although the Expert Panel agreed that the recommendations should be endorsed, two concerns were noted.

1. That the recommendations on surgical volumes should be changed from:
    - Surgical volumes in the range of 20 esophagectomy cases per unit per year and 150 pulmonary resections per unit per year should be considered targets for Level 1 centres.
    - Surgical volumes in the range of 7 esophagectomy cases per unit per year and 50 pulmonary resections per unit per year should be considered targets for Level 2 centres.

To:

- Surgical volumes of a minimum of 20 esophagectomy cases per unit per year and 150 pulmonary resections per unit per year should be considered targets for Level 1 centres.
- Surgical volumes of a minimum of 7 esophagectomy cases per unit per year and 50 pulmonary resections per unit per year should be considered targets for Level 2 centres.

The original and the revisions to the surgical volume targets are based on the expert opinion of the guideline panels. The updated literature review did not provide any new data to inform these recommendations. The Expert Panel noted that although the newly reviewed literature did not provide a basis in evidence for revising the target volume of 7 esophagectomy cases per unit per year for Level 2 centres, the literature should be monitored and the volumes should be revised as new evidence emerges.

2. That wedge resections for lung cancer were being performed outside of Level 1 and Level 2 centres in the province. After discussion, the Expert Panel believed that this is likely due to a misunderstanding of the recommendations under the subheading, "Volume of Thoracic Surgery." The original recommendations stated that "…150 anatomic pulmonary resections per unit per year…" were required for Level 1 status and "…50 anatomic pulmonary resections per unit per year…" were required for Level 2 status. The Expert Panel noted that the original recommendations were meant to include all pulmonary resections for lung cancer, including wedge resections. The Expert Panel agreed that word "anatomic" be deleted and that this change should be explicitly noted in the original guideline recommendations.

Ontario
Cancer Care Ontario
Action Cancer Ontario

Document Review Tool

Number and title of document under review	EBS 17-1 - Thoracic Surgical Oncology Standards
Current Report Date	September 9, 2005
Clinical Expert	Dr. Sudhir Sundaresan
Research Coordinator	Adam Haynes
Date Assessed	November 22, 2013
Approval Date and Review Outcome (once completed)	ENDORSED on March 4, 2014

Original Question(s):
What is the optimum organization for the delivery of cancer-related thoracic surgery in Ontario?

Target Population:
Not specifically stated in original guideline.
Scope of Standards: "The following standards, developed by the Expert Panel on Thoracic Surgical Oncology, apply to thoracic surgical oncology and include the full spectrum of multi-disciplinary assessment and treatment."

Study Section Criteria:
Inclusion Criteria:
Reports were selected for inclusion in this systematic review of the evidence if they reported information on organizational resources relating to improved outcomes for patients undergoing cancer-related thoracic surgery. Patient-related outcomes of interest include: tumour response, local disease control, survival, adverse events, or quality of life.
Practice guidelines, meta-analyses, or systematic reviews related to the research question were also eligible for inclusion in the systematic review of the evidence.
Exclusion Criteria:
Articles were excluded from the systematic review of the evidence if they reported information on thoracic surgeries for tumours in locations other than the lung or esophagus, if they were published or developed prior to 1990 and/or were in a language other than English.

Search Details:
For the methods used to develop the literature search strategy and to screen citations, please see Appendix 1.
Search Strategies:
Medline (OVID) (2004 to November Week 3, 2013 [December 23, 2013]):

1. general surgery/
2. surgery/
3. surgical procedures, operative/
4. (surger$ or (surgical$ adj (procedure$ or operation$ or resect$))).ti,ab.
5. or/1-4
6. exp lung neoplasms/
7. exp pleural neoplasms/
8. exp thymus neoplasms/
9. exp thymoma/
10. exp mesothelioma/
11. (NSCLC$ or SCLC$).ti,ab.
12. ((pulmonary or lung$ or thym$ or pleural$) adj3 (cancer$ or carcninom$ or adenocarcinom$ or neoplas$ or malignan$ or tumo?r$)).ti,ab.
13. ((malignan$ adj5 pleural$ adj5 mesothelioma$) or MPM$).ti,ab.
14. thymoma$.ti,ab.

15. esophageal neoplasms/
16. ((esophag$ or oesphag$) adj3 (cancer$ or carcinoma$ or adenocarcinom$ or neoplas$ or malignan$ or neoplas$)).ti,ab.
17. or/6-16
18. 5 and 17
19. thoracic surgery/
20. thoracotomy/
21. esophagectomy/
22. pneumonectomy/
23. esophagectom$.ti,ab.
24. oesophagectom$.ti,ab.
25. pneumonectom$.ti,ab.
26. thoracotom$.ti,ab.
27. ((esophag$ or oesophag$) adj3 (surger$ or resection$ or operation$)).ti,ab.
28. (thora$ adj3 (surger$ or operation$ or resection$)).ti,ab.
29. (lung$ adj5 volume$ adj5 reduction$).ti,ab.
30. lobectom$.ti,ab.
31. exp lung neoplasms/su
32. exp pleural neoplasms/su
33. exp thymus neoplasms/su
34. exp thymoma/su
35. esophageal neoplasms/su
36. mesothelioma/su
37. or/19-36
38. 18 or 37
39. (volume$ adj2 (standard$ or outcome$ or mortalit$ or operati$)).ti,ab.
40. (cancer adj (centre$ or center$)).ti,ab.
41. (teaching adj2 (status or hospital$)).ti,ab.
42. (designated adj (centre$ or center$ or hospital$ or site$)).ti,ab.
43. (thoracic adj2 surgeon$).ti,ab.
44. ((surgical$ or surgeon$) adj2 (volume$ or workload$ or experience$ or train$ or standard$ or requirement$ or guideline$ or qualit$ or special$ or subspecial$)).ti,ab.
45. ((hospital$ or site$ or center$ or centre$) adj2 (volume$ or standard$ or requirement$ or guideline$ or qualit$ or special$ or subspecial$)).ti,ab.
46. ((practice$ or organi?ation$ or resource$ or train$) adj2 (requirement$ or standard$ or guideline$ or volume$ or workload$ or experience$)).ti,ab.
47. exp "outcome and process assessment (health care)"/
48. health services administration/ or "organization and administration"/ or efficiency, organizational/ or health facility administration/ or centralized hospital services/ or surgery department, hospital/ or models, organizational/ or workload/ or "delivery of health care"/ or clinical competence/ or guideline adherence/ or exp "outcome and process assessment (health care)"/ or peer review, health care/ or "professional review organizations"/ or exp program evaluation/ or exp guidelines as topic/
49. exp Hospitals/
50. multidisciplinary.ti,ab.
51. patient care team/
52. (patient adj care).ti,ab.
53. (patterns adj5 care).ti,ab.
54. or/39-53
55. 38 and 54
56. (comment or letter or editorial or note or erratum or news or newspaper article or case report).pt.
57. 55 not 56
58. limit 57 to english language
59. (2004$ or 2005$ or 2006$ or 2007$ or 2008$ or 2009$ or 201$).ed.
60. 58 and 59

EMBASE (OVID) (2004 to 2013 Week 51 [December 23, 2013]):

1. (surger$ or (surgical$ adj (procedure$ or operation$ or resect$))).ti,ab.
2. *surgery/ or cancer surgery/ or general surgery/ or thorax surgery/
3. 1 or 2
4. exp lung cancer/
5. exp pleura tumor/
6. exp thymoma/
7. malignant mesothelioma/
8. (NSCLC$ or SCLC$).ti,ab.
9. ((pulmonary or lung$ or thym$ or pleural$) adj3 (cancer$ or carcninom$ or adenocarcinom$ or neoplas$ or malignan$ or tumo?r$)).ti,ab.
10. ((malignan$ adj5 pleural$ adj5 mesothelioma$) or MPM$).ti,ab.
11. thymoma$.ti,ab.
12. exp esophagus tumor/
13. ((esophag$ or oesphag$) adj3 (cancer$ or carcinoma$ or adenocarcinom$ or neoplas$ or malignan$ or neoplas$)).ti,ab.
14. or/4-13
15. 3 and 14
16. thorax surgery/
17. thoracotomy/

18. esophagus resection/
19. lung resection/
20. esophagectom$.ti,ab.
21. oesophagectom$.ti,ab.
22. pneumonectom$.ti,ab.
23. thoracotom$.ti,ab.
24. ((esophag$ or oesophag$) adj3 (surger$ or resection$ or operation$)).ti,ab.
25. (thora$ adj3 (surger$ or operation$ or resection$)).ti,ab.
26. (lung$ adj5 volume$ adj5 reduction$).ti,ab.
27. lobectom$.ti,ab.
28. exp lung cancer/su
29. exp pleura tumor/su
30. exp thymoma/su
31. malignant mesothelioma/su
32. exp esophagus tumor/su
33. or/16-32
34. 14 or 33
35. (volume$ adj2 (standard$ or outcome$ or mortalit$ or operati$)).ti,ab.
36. ((surgical$ or surgeon$) adj2 (volume$ or workload$ or experience$ or train$ or standard$ or requirement$ or guideline$ or qualit$ or special$ or subspecial$)).ti,ab.
37. (teaching adj2 (status or hospital$)).ti,ab.
38. (cancer adj (centre$ or center$)).ti,ab.
39. (designated adj (centre$ or center$ or hospital$ or site$)).ti,ab.
40. (thoracic adj2 surgeon$).ti,ab.
41. ((surgical$ or surgeon$) adj2 (volume$ or workload$ or experience$ or train$ or standard$ or requirement$ or guideline$ or qualit$ or special$ or subspecial$)).ti,ab.
42. ((hospital$ or site$ or center$ or centre$) adj2 (volume$ or standard$ or requirement$ or guideline$ or qualit$ or special$ or subspecial$)).ti,ab.
43. ((practice$ or organi?ation$ or resource$ or train$) adj2 (requirement$ or standard$ or guideline$ or volume$ or workload$ or experience$)).ti,ab.
44. *hospital/ or *health care facility/ or community hospital/ or general hospital/ or high volume hospital/ or low volume hospital/ or teaching hospital/
45. clinical competence/
46. patient care/ or organizational efficiency/
47. *health care organization/
48. health care facility/ or health care organization/
49. or/35-48
50. 34 and 49
51. (letter or comment or note or erratum or editorial).pt.
52. 50 not 51
53. limit 52 to english language
54. (2004$ or 2005$ or 2006$ or 2007$ or 2008$ or 2009$ or 201$).ew.
55. 53 and 54

Also searched: Cochrane library via OVID (CDSR [Nov 2013]; CCTR [Nov 2013], and DARE [4th Quarter, 2013]).

Brief Summary/Discussion of New Evidence:

A total of 19,263 citations were identified from MEDLINE, EMBASE, CDSR, CCTR, and DARE via OVID. Of those, 308 were selected for full text review. A total of 105 publications met the inclusion criteria, 4 publications were irretrievable, and 199 publications were excluded. A further 8 publications were identified from the reference lists of included studies that were not identified in the searches of MEDLINE and EMBASE (Committee for Scientific Affairs et al, *Gen Thorac Cardiovasc Surg* 2007;55(12):483-92; Dillman et al, *J Oncol Pract* 2005;1(3):84-92; Forrest et al, *Br J Cancer* 2005;93(9):977-8; Gordon et al, *J Am Coll Surg* 1999;189(1):46-56; Halm et al, *Ann Intern Med* 2002;137(6):511-20; Hollenbeck et al, *J Clin Oncol* 2007;25(1):91-6; Kee et al, *Med Decis Making* 2004;24(6):602-13; Murray et al, *Lung Cancer* 2003;24(3):283-90).

Of the 113 identified publications there were 14 publications of 11 systematic reviews. The remaining 99 publications were of primary studies. The results of the systematic reviews can be found in Table 1. The results of the 43 publications of primary studies that were not included in at least one of the identified systematic reviews can be found in Table 2. The remaining 56 primary studies were included in at least one of the identified systematic reviews—the results of those studies are not reported here separately. Appendix 2 consists of a bibliography of those studies.

Table 1. Systematic reviews meeting inclusion criteria for EBS #17-1.

Author, year (reference)	Inclusion Criteria	Methods	Intervention/ Comparison	Outcomes of Interest	Brief Results
Hospital Volume, Surgeon Volume or Surgeon Specialty					
Pieper, 2013 (1) **Systematic review of systematic reviews** ***Esophageal and Lung Cancer***	SRs investigating relationship between hospital volume and outcomes for cancer surgery	Lit Search: July 2012. Strategy provided in article. Searched Medline, Embase, CDSR, DARE, HTA database and websites of HTA organizations. Assessed quality using AMSTAR	Hospital volume (excluded studies that reported only on surgeon volume or reported only pooled data for hospital and surgeon volume combined)	Clinical outcomes (authors did not specify further)	***Esophageal Cancer:*** 1 SR and MA: Wouters, 2012 (2)-see below 4 SRs: Gruen, 2009 (3)-see below Gandjour, 2003[A] Halm, 2002[B] Dudley, 2000[C] Based on the results of the Wouters 2012 MA (see below), the authors felt that the evidence for HVH as a determinant for post-op mortality was strong; however, they noted that statistical heterogeneity was present. ***Lung Cancer:*** 1 SR and MA: von Meyenfeldt, 2012 (4)-see below 1 SR: Halm, 2002[B] Based on the results of the von Meyenfeldt MA (see below), the authors felt that the evidence indicates that post-op mortality improved significantly in HVH, but that the evidence was less convincing for survival.
Markar, 2012 (5) and Centre for Reviews and Dissemination, 2013 (6) **Systematic review and meta-analysis** ***Esophageal Cancer***	Studies of patients who had surgical treatment for esophageal cancer since the year 2000, and compared LVH to HVH (with specifically stated thresholds) for the outcomes of interest.	Lit search: 1966-2011. Search terms provided in article. Searched Medline, Embase and conference proceedings from several professional organizations. No formal methods for assessing quality of the included studies were reported.	Hospital volume Included studies had to specifically state the volume thresholds to determine LVH and HVH.	Primary: In-hospital mortality; 30-day mortality. Secondary: length of hospital stay; post-operative complications.	Nine studies, with 12,130 resections at LVHs (range <4 to <78 resections/year) and 15,713 resections at HVHs (range >9 to >346 resections/year), were included: Al-Sariria, 2007[D] Funk, 2011[D] Fujita, 2010[D] Committee for Scientific Affairs, 2007[D] Lin, 2006[D] Reavis, 2008[D] Stavrou, 2010[D] Suzuki, 2011[D] Wouters, 2009[D] ***Meta-analysis results:*** In-hospital mortality (8 studies, with 12,083 LVH and 15,558 HVH resections): pooled OR 0.29, 95% CI 0.16-0.53, p<0.0001, for HVH vs. LVH; high statistical heterogeneity, p<0.0001, I^2=95.2%. 30-day mortality (2 studies, with 4063 LVH and 2880 HVH resections): pooled OR 0.31, 95% CI 0.19-0.51, p<0.0001, for HVH vs. LVH; no statistical heterogeneity, p=0.76. LOS (2 studies, with 541 LVH and 4,087 HVH resections): weighted mean difference -4.33, 95% CI -12.37 to 3.70, p=0.29, for HVH vs. LVH; statistical heterogeneity, p<0.0001. Post-operative complications (3 studies, with 588 LVH and 4242 HVH resections): pooled OR 0.62, 95% CI 0.37-1.05, p=0.08, for HVH vs. LVH; statistical heterogeneity, p=0.04.
Wouters, 2012 (7) **Systematic review and meta-analysis**	Studies investigating the volume-outcome relation in esophageal cancer surgery. Studies	Lit search: January 1 1995 to July 1, 2010. Search strategy (PubMed) provided in article.	Hospital volume and surgeon volume. Included studies had to specifically state	Post-op mortality and survival.	43 studies were included. The volume categories varied greatly between the studies. **Hospital volume:** ***Post-operative mortality:***

Esophageal Cancer	had to use primary data, report a comparison between hospitals (volume) or surgeons (volume), report the cutoff values used, and report post-operative morbidity, mortality, survival or QOL. Studies could not describe the results of just a single hospital or surgeon.	Searched Medline (PubMed). Assessment of study quality was done using the STROBE checklist. Only high-quality studies were included in the meta-analysis (defined as a multicenter study with a multivariate analysis including case mix factors such as patient demographics, comorbidities, tumour characteristics, and urgency of operation). Studies without a multivariate analysis and/or that did not report OR, HR or risk rates were excluded from the meta-analysis.	the volume thresholds.		Of 32 studies comparing mortality by hospital volume, 24 studies found a significant difference in mortality in favour of HVH compared to LVH and 8 studies reported no significant difference. *Meta-analysis:* Pooled OR (16 studies): 2.30 95% CI 1.89-2.80, for LVH (range 1 to <19 surgeries/year) compared to HVH (range >2 to >86 surgeries/year); statistical heterogeneity: I^2=60%, p=NR; but authors stated that there was moderate heterogeneity. ***Survival:*** Of 7 studies comparing survival by hospital volume, 4 studies found a significant difference in survival in favour of HVH compared to LVH and 3 studies reported no significant difference. *Meta-analysis:* Pooled HR (4 studies): 1.17 95% CI 1.05-1.31 for LVH (range 1 to <9 surgeries/year) compared to HVH (range >7 to >44 surgeries/year); statistical heterogeneity: I^2=0, p=NR; but authors reported that the result was homogeneous. **Surgeon volume:** ***Post-operative mortality:*** Of 9 studies comparing mortality by surgeon volume, 5 studies found a significant difference in mortality in favour of high volume surgeons compared to low volume surgeons and 4 studies reported no significant difference. Meta-analysis: Pooled OR (3 studies): 1.55 95% CI 0.88-2.75 for low volume surgeons (1 surgery/year) compared to high volume surgeons (range ≥6 to ≥7 surgeries/year); statistical heterogeneity: I^2=75%, p=NR; authors reported result as "very heterogeneous". ***Survival:*** Of 4 studies comparing survival by surgeon volume, 2 studies found a significant difference in survival in favour of high volume surgeons compared to low volume surgeons and 2 studies reported no significant difference. *Meta-analysis:* Pooled HR (2 studies): 1.16 95% CI 0.94-1.45 for low volume surgeons (≤9 surgeries/year) compared to high volume surgeons (≥10 surgeries/year); statistical heterogeneity: I^2=48%, p=NR; but authors reported moderate heterogeneity.
von Meyenfeldt, 2012 (4) and von Meyenfeldt, 2011 (8) **Systematic review and meta-analysis** ***Lung Cancer***	Studies of patients who received surgical treatment of lung cancer, and compared outcomes between providers (hospitals or surgeons with distinct volume thresholds or clearly defined specialty)	Lit Search: January 1, 1990-January 20, 2011. Search strategy provided in article. Searched Medline (PubMed) and the Cochrane Library. Study quality was assessed using the STROBE checklist, but the results were not reported.	Hospital volume, surgeon volume, surgeon specialty. Included studies had to specifically state volume thresholds for hospitals and surgeons or clearly define surgeon specialty.	Post-operative mortality or survival.	19 studies were included. ***Hospital Volume:*** <u>Post-operative mortality:</u> 5 of 11 studies found a significant inverse relationship between hospital volume and 30-day or in-hospital mortality. *Pooled OR* (10 studies) 0.71, 95% CI 0.62-0.81, for HVH (range >21 to >116 surgeries/year) compared to LVH (range <4 to <43 surgeries/year). <u>Survival:</u> *Pooled HR* (7 studies) 0.93, 95% CI 0.84-1.03, I^2=85%, for HVH (range >21 to >84 surgeries/year) compared to LVH (range <4 to <40 surgeries/year). ***Surgeon Volume:*** <u>Post-operative mortality:</u> 1 of 2 studies showed a significant result favouring HVH.

					Pooled OR (2 studies) 0.68, 95% CI 0.42-1.08, I^2=66%, for high volume surgeons (>18 and >26 surgeries/year) compared to low volume surgeons (<6 and <9 surgeries/year). ***Surgeon Specialty:*** Post-operative mortality: Thoracic surgeons vs. General surgeons: pooled OR (3 studies) 0.78, 95% CI 0.70-0.88 Cardiothoracic surgeons vs. general surgeons: *Pooled OR* (3 studies) 0.82, 95% CI 0.69-0.96 Survival: Thoracic surgeon vs. general surgeon: *Pooled HR* (2 studies) 0.86, 95% CI 0.74-1.00, I^2=28%
Rouvelas, 2010 (9) **Systematic review** ***Esophageal Cancer***	Studies of patients with esophageal cancer who had undergone surgery as part of their treatment, defined either hospital or surgeon volume, and reported on one at least one outcome of interest	Lit Search: Early 1980's to unknown. Search terms (keywords) were provided in the article. Searched Medline (PubMed). No formal methods for assessing quality of the included studies were reported.	Hospital volume or surgeon volume.	In-hospital mortality, long-term prognosis, post-operative complications, HRQoL, health economy.	The authors did not report the total number of included studies or include a PRISMA flow diagram. ***Hospital Volume:*** Post-operative mortality: 13 studies included. Post-operative complications: 12 studies included. Survival: 6 studies included. HRQoL: Two studies included. ***Surgeon Volume:*** Post-operative mortality: 6 studies included. Post-operative complications: Unclear number of studies. Survival: No studies included. HRQoL: No studies included. Note: the reporting of the number of included studies as well as data for outcomes in the included studies was inconsistent and it was not possible to determine the number of studies with statistically significant differences for any of the above outcomes. Authors concluded that the studies to date demonstrate that higher volume centres have lower post-operative morbidity and mortality, but there is no evidence of improvement to long-term outcomes such as survival or HRQoL. Surgeon volume also has an impact on outcomes. The authors suggest that volume may be a surrogate of other variables that are related to management of patients after surgery such as MCCs, experienced surgeons, high-quality post-operative care, skilled medical staff, and a well-established process of care. There is no defined cut-off for the lowest recommended annual volume.
Gruen, 2009 (3) **Systematic review and meta-analysis** ***GI cancer***	SRs, MAs, RCTs, controlled trials, comparative studies, and cohort studies including patients with GI cancers who received surgical treatment in high-volume hospitals or by high-volume surgeons.	Lit search: 1966-May 2007 (start date varied depending on database). Complete search strategy provided in article. Searched Medline (OVID), Embase, Australasian Medical Index, Cochrane Library, EconLit, PubMed, and ISI Web of Knowledge.	Hospital volume (high vs. low) or surgeon volume (high vs. low).	Short-term (30-day or in-hospital) mortality and long-term mortality.	A total of 28 studies that investigated esophageal cancer were included. Used unadjusted data in meta-analysis. **Meta-analysis** ***Hospital Volume:*** Short-term mortality: 16 of 26 studies demonstrated a significant difference in favour of HVH (threshold NR) compared to LVH (threshold NR). Pooled OR (24 studies) for effect on mortality of doubling the hospital case volume: 0.81, 95% CI 0.77-0.84, in favour of HVH (>18 surgeries/year) compared to LVH (<3 surgeries/year).

		Studies were critically appraised to determine the risk of bias by assessing study type, whether the analysis accounted for clustering effects, and whether important confounders were considered.			Long-term mortality: 2 of 6 studies demonstrated a significant difference in favour of HVH (volume cut-offs NR) No meta-analysis was conducted due to the small number of studies. ***Surgeon Volume:*** Short-term mortality: 6 of 6 studies demonstrated a significant difference in favour of high-volume surgeons (range 1 to <47 surgeries/year) compared to low-volume surgeons (range >4 to >48 surgeries/year). No meta-analysis was conducted due to the small number of studies. Long-term mortality: 0 of 2 studies demonstrated a significant difference between high-volume and low-volume surgeons (volume cut-offs NR). No meta-analysis was conducted due to the small number of studies.
Wouters, 2009 (2) **Systematic review** ***Esophageal Cancer***	Studies comparing mortality rates after esophagectomy between hospitals with a lower and higher procedural volume.	Lit search: 1998-2008. Search terms (keywords) provided in the article. Searched Medline. No formal methods for assessing the quality of the included studies were reported.	Hospital volume (high vs. low).	Mortality (in-hospital or 30-day).	A total of 24 studies investigating hospital volume-mortality were included. Mortality: 21 studies reported a significant difference in hospital mortality in favour of HVH (range >2 to >86) compared to LVH (range 1 to <30).
Killeen, 2005 (10) **Systematic review** ***Cancer***	Systematic reviews or community or population-based cohort studies including patients with cancer who received surgical treatment and compared outcomes of interest using hospital volume as the independent variable. Single-institution studies and case series were excluded.	Lit search: 1984-2004. Search terms (keywords) provided in the article. Searched Medline, Embase, and the Cochrane Library. Study quality was assessed using a system by Halm et al[†].	Hospital volume (high vs. low) and surgeon volume (high vs. low).	Mortality (30-day).	***Esophageal Cancer:*** 10 studies investigating esophageal cancer were included. Hospital volume: Mortality: 8 of 9 studies found a statistically significant difference in mortality in favour of HVH (range >6 to >83 surgeries/year) compared to LVH (range <2 to <13 surgeries/year). Surgeon volume: 2 of 3 studies found a statistically significant difference in mortality in favour of high-volume surgeons (range >6 to >15 surgeries/year) compared to low volume surgeons (range <2 to <6 surgeries/year). ***Lung Cancer:*** 10 studies investigating lung cancer were included. Hospital volume: Mortality: 4 of 9 studies found an inverse relationship between volume and mortality. Surgeon volume: Mortality: 2 of 3 studies reported that no statistically significant relationship between surgeon volume and mortality was found.
Metzger, 2004 (11) **Systematic review and meta-analysis**	No explicit inclusion criteria were reported. Studies investigating patients who had	Lit search: 1990-2003. Search terms (keywords) provided in the article.	Hospital volume (e.g., high vs. low)	Mortality (in-hospital or 30-day)	13 studies were included and combined in a meta-analysis. No individual study results were reported. **Meta-analysis** ***Hospital volume:*** Mortality:

Esophageal Cancer	esophagectomies and compared mortality using hospital volume as the independent variable were included.	Searched Medline, Current Contents and First Search Social Abstracts.			8 studies were included in the meta-analysis. A total of 18,032 patients provided an OR of 0.43 (95% CI 0.31-0.58) for hospitals with >20 esophagectomies/year compared to hospitals with ≤20 esophagectomies/year. OR<1 favours HVH (i.e., reduced risk of mortality). The authors did not report a statistical test for heterogeneity.
Other					
Croke, 2012 (12) **Systematic review** ***Lung Cancer***	PGs, SRs, MAs, trials, or prospective or retrospective studies of the impact of MCCs on clinical decision-making and patient outcomes in patients with cancer	Lit Search: 1950-June 2010. Strategy provided in article. Searched Medline.	Use of MCCs.	Clinical decision-making, patient management, clinical outcomes	Lung Cancer: 1 SR: Coory, 2008 (13) Assessed the effectiveness of MCCs in lung cancer. 16 studies met the inclusion criteria, of which 2 reported an improvement in survival in favour of MCC. – See below 3 prospective studies: Leo, 2007[D] In 344 patients, discussion at MCCs led to discordance in 15 cases (4.4%), with a non-significant trend to shorter survival being associated with that discordance (p=0.07). Forrest, 2005[D] Compared survival before and after implementation of MCC, and found that median survival increased after implementation (before, 3.2 months vs. after, 6.6 months; p<0.002) Kee, 2004[D] In 50 patients, MCCs did not improve the overall quality of clinical decision-making. The authors concluded that the published literature supports that MCCs lead to changes in diagnoses and physician management decisions—*for all cancers*. The authors also stated that no strong prospective evidence yet exists to suggest that MCCs improve patient outcomes.
Coory, 2008 (13) **Systematic review** ***Lung Cancer***	Any study that mentioned a team working among specialists with diagnostic and therapeutic intent, where the members met at a specified time, either in person or by video or teleconferencing, to discuss the diagnosis and management of patients with suspected lung cancer.	Lit Search: 1984 to July 2007. Search terms (keywords) provided in article. Searched Medline (OVID).	Use of MDTs	Survival	Identified 16 studies: 1 RCT Murray, 2003[D]: Compared rapid assessment (CT scan, tissue biopsy then review by MDT after 3 working days) to standard care (investigated at local clinics under the care of a specialist lung cancer physician) in 88 patients with suspected lung cancer. The authors found no statistically significant difference in 2-year survival between the two groups (33% vs. 40%, MDT vs. non-MDT; p=0.7). 7 Before-and-After Studies: *4 of these measured survival, of which only two found a statistically significant difference:* Price, 2002[E]: 1-year survival increased from 18.3% to 23.5% after introduction of MDTs and site specialization (statistically significant at p=0.049). NOTE: this is an abstract-only publication that investigated the affect of MDTs on use of radiotherapy. Forrest, 2005[D]: Median survival increased from 3.4 months to 6.6 months after introduction of MDT, p<0.001. *And 2 studies did not find a statistically significant difference:* Martin-Ucar, 2004[F]: 1-year survival was similar before (63%) and after (62%) introduction of MDT meetings.

					5-year survival was similar before (31%) and after (32%) introduction of MDT meetings. Dillman, 2005[D]: 5-year survival increased from 16% to 19% after opening an affiliated facility and weekly MDT meetings, p=0.012. Median survival increased from 11 months to 13 months, p=0.032. Differences in these crude rates were attributed to the significant increase in the number of patients with early stage disease.

Notes: GI=gastrointestinal; HR=hazard ratio; HRQoL=health-related quality-of-life; HVH=high-volume hospital; LOS=length of hospital stay; LVH=low-volume hospital; MA=meta-analysis; MCC=multi-disciplinary cancer conference; MDT=multi-disciplinary team; OR=odds ratio; PG=practice guideline; SR=systematic review.

[A]This systematic review was excluded as the literature search included studies prior to 1990: Gandjour A, Bannenberg A, Lauterbach KW. Threshold volume associated with higher survival in health care. A systematic review. Med Care. 2003;41(10):1129-41.

[B]This systematic review was not reported further as it was published prior to the cutoff date of the literature search in the original 17-1 guideline: Halm EA, Lee C, Chassin MR. Is volume related to outcome in health care? A systematic review and methodologic critique of the literature. Ann Intern Med. 2002;137(6):511-20.

[C]This systematic review was excluded as the literature search included studies prior to 1990: Dudley RA, Johansen KL, Brand R, Rennie DJ, Milstein A. Selective referral to high-volume hospitals. Estimating potentially avoidable deaths. JAMA. 2000;283(9):1159-66.

[D]This primary study was not included in Table 2 below as it was included in a published systematic review. See Appendix 1 for a complete bibliography of primary studies that were included in at least one of the systematic reviews in Table 1.

[E]This study was excluded from the 17-1 update as it investigated the affect of MDTs on radiotherapy and not surgery: Price A, Kerr G, Gregor A, Ironside J, Little F. The impact of multidisciplinary teams and site specialisation on the use of radiotherapy in elderly people with non-small cell lung cancer (NSCLC) [abstract]. Radiother Oncol. 2002;64(Suppl 1):S80.

[F]This study was excluded from the 17-1 update as it was included in the orginial 17-1 guideline: Martin-Ucar AE, Waller DA, Atkins JL, Swinson D, O'Byrne KJ, Peake MD. The beneficial effects of specialist thoracic surgery on the resection rate for non-small-cell lung cancer. Lung Cancer. 2004 Nov;46(2):227-32.

Table 2. Primary studies meeting inclusion criteria for EBS #17-1.

Author, year, etc	Procedure and population	Methods	Intervention	Outcomes of interest	Brief results
Hospital volume					
Finley, 2010 (14) **Lung Cancer**	Patients aged 18 years and older who underwent pulmonary lobectomy from 1999 to 2007 in Canada.	Retrospective cohort from the Canadian Institute for Health Information Discharge Abstract Database. Compared LOS and in-hospital mortality by hospital volume (both between and within hospitals). In-hospital mortality analyzed by random effects logistic regression and LOS analyzed by random effects linear regression of log-transformed LOS. An unadjusted regression was performed to examine trends in outcomes over time. The effect of annual hospital volume on outcomes was examined by modeling yearly hospital volume by LOS and in-hospital mortality and by adjusting for calendar year, gender, age, Charlson comorbidity index, province of care,	In the multivariate model, volume was analyzed as a continuous variable.	In-hospital mortality, LOS	**Pulmonary lobectomies:** 19,732 patients. Pre-operatively, 82.8% had a diagnosis of cancer. ***In-hospital mortality:*** 1999: 3.1% vs. 2007: 1.95% Unadjusted analysis: 45% relative risk reduction (95% CI 21-61; p=0.001) over the study period. Risk-adjusted analysis (gender, age, Charlson index): 15% relative risk reduction (95% CI 9-19; p<0.0001) in in-hospital mortality for every 20 additional cases performed per hospital. *Within-hospital changes in volume:* -5% relative decrease in mortality for each additional 20 cases performed in a given hospital (95% CI 6 to -18; p=0.39). ***LOS:*** 1999: 10.4 days (SD 12.2 days) vs. 2007: 8.9 days (SD 10.1 days). Unadjusted analysis: 19% relative risk reduction (95% CI 12-25; p<0.0001) over the study period. Risk-adjusted analysis (gender, age, Charlson index): 5% relative risk reduction (95% CI 3-7; p<0.001) in LOS for every 20 additional cases performed per hospital. *Within-hospital changes in volume:* 4% relative decrease in LOS for each additional 20 cases performed within a given hospital (95% CI 1-6; p=0.0005).

		and the average volume per hospital over the study period.			
Kozower, 2011 (15) **Lung Cancer**	Patients who underwent surgical treatment for lung cancer in 2007.	Retrospective cohort from the HCUP-NIS (U.S.) comparing inpatient mortality by hospital volume. Hierarchical generalized linear models, adjusted by patient age, gender, and comorbid disease: 3 models: 1) volume as linear effect; 2) volume as nonlinear effect, restricted cubic spline; 3) volume as nonlinear effect, quintiles.	Volume cutoffs (annual): 1-2, 3-6, 7-12, 13-23, ≥24	Inpatient mortality	**Lung resections:** 7908 discharge records representing 40,460 lung cancer resections in the weighted data set. ***Inpatient mortality:*** *Linear effect:* OR: 1.01 95% CI 1.00-1.02 *Non-linear, restricted cubic splines:* OR: 1.89 95% CI 0.00-99.9 *Non-linear, quintiles:* 1-2 vs. ≥24: OR 3.52 95% CI 0.92-13.52 3-6 vs. ≥24: OR 0.85 95% CI 0.23-3.14 7-12 vs. ≥24: OR 0.82 95% CI 0.20-3.30 13-23 vs. ≥24: OR 0.37 95% CI 0.10-1.41
Luchtenborg, 2013 (16) **Lung Cancer**	Patients who underwent surgical treatment for lung cancer in 2004-2008 in England.	Retrospective cohort from the National Cancer Data Repository (NCDR) in England from 2004-2008 comparing survival between hospital volume quintiles. Multivariable Cox proportional hazards regression analyses adjusted by sex, age, SES-deprivation score, Charlson comorbidity, and volume quintile. A shared frailty Cox model was used, with hospital as a random effect to account for the risk of death varying between groups of patients treated within a given hospital.	Volume cutoffs (annual): <70, 70-99, 100-129, 130-149, ≥150	Survival	**Lung resections:** <70: 2582 patients in 44 hospitals 70-99: 2662 patients in 13 hospitals 100-129: 2378 patients in 11 hospitals 130-149: 2651 patients in 9 hospitals ≥150: 2589 patients in 6 hospitals *Multivariable Cox model:* 70-99 vs. <70: HR 0.90 95% CI 0.83-0.98 100-129 vs. <70: HR 0.93 95% CI 0.85-1.01 130-149 vs. <70: HR 0.91 95% CI 0.83-0.98 ≥150 vs. <70: HR 0.83 95% CI 0.76-0.91 *Shared frailty Cox model:* 70-99 vs. <70: HR 0.86 95% CI 0.77-0.97 100-129 vs. <70: HR 0.90 95% CI 0.79-1.02 130-149 vs. <70: HR 0.89 95% CI 0.78-1.02 ≥150 vs. <70: HR 0.78 95% CI 0.67-0.90
Otake, 2011 (17) **Lung Cancer**	Patients with lung cancer who underwent lobectomy between July and December in 2007 and 2008.	Cross-sectional survey of 926 and 855 teaching hospitals in 2007 and 2008 in Japan comparing in hospital mortality and post-operative LOS by hospital volume categories. In-hospital mortality was compared between each subcategory by chi-squared test. Logistic regression, adjusted for sex, age, and comorbidities, was use to determine effect of hospital volume on in-hospital mortality.	Volume cutoffs (annual): Low: ≤24 Medium-low: 25-43 Medium-high: 44-67 High: ≥68	In-hospital mortality, post-operative LOS	**Lobectomies:** Low: 5013 patients in 327 hospitals Medium-low: 5127 patients in 87 hospitals Medium-high: 4856 patients in 55 hospitals High: 4835 patients in 27 hospitals ***In-hospital mortality:*** Low: 0.94% Medium-low: 0.62% Medium-high: 0.72% High: 0.48% P=0.044 *Logistic regression:* Medium-low vs. low: OR: 0.68 95% CI 0.43-1.08 Medium-high vs. low: OR: 0.82 95% CI 0.53-1.28 High vs. low: OR: 0.60 95% CI 0.36-0.99 ***Post-operative LOS:*** *Mean days:* Low: 15.9 95% CI 15.5-16.3 days

		Post-operative LOS was compared between the four volume groups using analysis of variance.			Medium-low: 13.1 95% CI 12.7-13.5 days Medium-high: 12.4 95% CI 12.0-12.7 days High: 11.5 95% CI 11.2-11.8 days *Logistic regression:* Medium-low vs. low: OR: 1.33 95% CI 1.28-1.38 Medium-high vs. low: OR: 1.39 95% CI 1.33-1.45 High vs. low: OR: 1.50 95% CI 1.44-1.56
Park, 2012 (18) Park, 2011 (19) abs **Lung Cancer**	Patients with lung cancer who underwent lobectomy (either video-assisted thoracoscopic surgery [VATS] or open) in 2008.	Retrospective cohort comparing complications, LOS, and in-hospital mortality by hospital volume for VATS and by surgical technique (VATS vs. open). Chi-squared test (unadjusted) to compare complications and Mann-Whitney test (unadjusted) to compare median LOS. Multivariable logistic regression models used to adjust for independent variables for complications and multivariable linear regression models used to adjust for significant independent variables for LOS.	Volume cutoff (annual): VATS: HVH: >20 LVH: ≤20	Complications, LOS, in-hospital mortality.	**VATS lobectomy:** 1,523 cases. HVH: 722 cases LVH: 801 cases *Median LOS:* Unadjusted: HVH: 4 days vs. LVH: 6 days; p=0.001 Adjusted OR: -0.90 95% CI -1.67 to -0.13; p=0.022 *Complications:* Unadjusted: HVH 38.1% vs. LVH: 38.5%; p=0.92 *Mortality:* Unadjusted: HVH 1.4% vs. LVH: 1.6%; p=0.83
Smithers, 2013 (20) abstract **Lung Cancer**	Patients who underwent surgical treatment for lung cancer from 2001-2010. This study also included patients who had surgery for pancreatic cancer or gastrointestinal cancer.	Retrospective cohort from 2001-2010 drawn from patients treated at hospitals in Queensland Australia comparing 30-day postoperative mortality between low and high volume hospitals. Proportional hazards regression analysis adjusted by demographic and clinical characteristics.	Volume cutoff (annual): The median annual hospital volume for lung resections was used as the cutoff for HVH vs. LVH. The median was NR.	30-day postoperative mortality	**Lung resections:** 2570 cases *30-day postoperative mortality:* HR: 4.8 95% CI 1.5-15.0, for LVH vs. HVH.
Yun, 2012 (21) **Lung Cancer**	Patients aged ≥20 years with lung cancer who underwent surgical treatment from 2001 through 2005. This study also included patients who had surgical treatment for cancer of the stomach, colon, rectum, pancreas, or breast.	Retrospective cohort from 2001 through 2005 with follow-up data through 2006 from the Korea Central Cancer Registry database and the National Health Insurance database in Korea. Compared overall survival by hospital volume. Multivariable Cox proportional hazards modeling to assess effect of hospital	Volume cutoff (annual): Low: NR Medium: NR High: NR	5-year survival	**Lung resections:** Number of cases: NR ***5-year survival:*** 50.1% for all patients with a lung resection. *Unadjusted HR:* 1.69 95% CI 1.56-1.84 for low or medium volume hospitals compared to high volume hospitals. *Adjusted HR:* 1.60 95% CI 1.47-1.74 for low or medium volume hospitals compared to high volume hospitals.

		volume on overall survival adjusted for age, sex, Charlson score, hospital type, insurance, radiotherapy, chemotherapy, type of medical care institution, year of diagnosis, and waiting time.			
Learn, 2010 (22) **Lung Cancer and Esophageal Cancer**	Patients aged 18 years or older who underwent esophagectomy for esophageal cancer or major lung resection for lung cancer in the U.S. This study also included pancreatic cancer and gastric cancer.	Retrospective cohort from the HCUP-NIS (U.S.) from 1997 to 2006 comparing inpatient mortality between time periods, by hospital volume, by hospital type (teaching vs. non-teaching). Logit-linked generalized estimating equations adjusted using Elixhauser comorbidity index.	Volume cutoffs (annual): Lung: High: >33 Medium: 17-33 Low: 1-16 Esophageal: High: >6 Medium: 3-6 Low: 1-2	Inpatient mortality	***Lung resections:*** 62,628 patients *Inpatient mortality:* Annual volume of procedures at treating hospital: OR (per case): 0.996 95% CI 0.994-0.998, p<0.001 Teaching vs. non-teaching: OR: 0.98 95% CI 0.88-1.09, p=0.73 ***Esophagectomies:*** 3476 patients *Inpatient mortality:* Annual volume of procedures at treating hospital: OR (per case): 0.95 95% CI 0.93-0.97, p<0.001 Teaching vs. non-teaching: OR: 1.22 95% CI 0.92-1.63, p=0.17
Allareddy, 2010 (23) **Esophageal Cancer**	Patients who underwent esophagectomy in the U.S. This study also included other surgical procedures.	Retrospective cohort study from the HCUP-NIS from 2000-2003 comparing complications and in-hospital mortality by hospital volume categories. Multivariable logistic regression models adjusting for age, sex, admission type, comorbid severity, primary diagnosis, extent/type of primary procedure, year of procedure, hospital teaching status and bed size. A second model for in-hospital mortality was also used that used the above plus adjusted for the effect of complications that were significantly associated with in-hospital mortality at the p=0.10 level.	Volume cutoffs (annual): Leapfrog Group cutoff: HVH: ≥13 LVH: <13	In-hospital mortality, complications.	***Esophagectomies:*** 2473 procedures in 555 hospitals. *Complications:* HVH vs. LVH: OR 1.03 95% CI 0.82-1.29 *In-hospital mortality:* OR (not adjusted for complications): 0.54 95% CI 0.33-0.86 OR (adjusted for complications): 0.53 95% CI 0.35-0.82
Finley, 2011 (24) **Esophageal Cancer**	Patients aged 18 years and older who underwent esophagectomies from 1998 to 2007 in Canada.	Retrospective cohort from the Canadian Institute for Health Information Discharge Abstract Database. Compared LOS and in-hospital mortality by	In the multivariate model, volume was analyzed as a continuous variable.	In-hospital mortality, LOS	**Esophagectomies:** 6985 patients. ***In-hospital mortality:*** 1998: 9.1% (95% CI 6.9% to 11.8%) vs. 2007: 3.6% (95% CI 2.4% to 5.1%)

		hospital volume (both between and within hospitals). In-hospital mortality analyzed by random effects logistic regression and LOS analyzed by random effects linear regression of log-transformed LOS. An unadjusted regression was performed to examine trends in outcomes over time. The effect of annual hospital volume on outcomes was examined by modeling yearly hospital volume by LOS and in-hospital mortality and by adjusting for year of procedure, gender, age, Charlson comorbidity index.			Unadjusted analysis: 64% decrease in the odds of in-hospital mortality (95% CI 51% to 74%; p=0.0001) over the study period. Risk-adjusted analysis (gender, age, Charlson index): 15% relative decrease (95% CI 6% to 23%; p=0.001) in in-hospital mortality for every 10 additional cases performed per hospital. LVH (≤6 procedures per year): 9.8% (95% CI 8.3% to 11.4%) HVH (>20 procedures per year): 4.8% (95% CI 4.1% to 5.6%) *Within-hospital changes in volume:* 4% relative decrease in mortality for each incremental increase in volume of 10 cases above average within a given hospital per year (95% CI -12% to 18%; p=0.58). ***LOS:*** 1998: 24.2 days (SD 21.9 days) vs. 2007: 17.3 days (SD 21.9 days). Unadjusted analysis: 38% decrease in the expected LOS (95% CI 34% to 43%; p<0.0001) over the study period. Risk-adjusted analysis (gender, age, Charlson index): 10% increase in LOS (95% CI 2% to 19%; p=0.01) for every 10 additional cases performed per hospital. *Within-hospital changes in volume:* 2% relative increase in LOS for each incremental increase in volume of 10 cases above average within a given hospital per year (95% CI -2% to 5%; p=0.34).
Dikken, 2012 (25) Dikken, 2011 (26) abs **Esophageal Cancer**	Patients with esophageal cancer who received surgical treatment in the Netherlands from 1989 through 2009. This study also included patients with gastric cancer surgeries.	Retrospective cohort from the Netherlands Cancer Registry comparing post-op mortality and survival by annual hospital volume for esophagectomy. Survival and 6-month mortality analyzed by Cox regression stratified for hospital volume and adjusted for factors used to analyze changes over time and for clustering of deaths within hospitals.	Volume cutoffs (annual): Very low: 1-5 Low: 6-10 Medium: 11-20 High: ≥21	Survival, 6-month mortality.	**Esophagectomies:** Very low: 2914 cases Low: 2695 cases Medium: 1494 cases High: 2922 cases *3-year Survival:* Low vs. Very low: HR 1.01 95% CI 0.94-1.10 Medium vs. Very low: HR 0.90 95% CI 0.81-0.99 High vs. Very low: HR 0.77 95% CI 0.70-0.85 *6-month Mortality:* Low vs. Very low: HR 0.90 95% CI 0.78-1.03 Medium vs. Very low: HR 0.78 95% CI 0.62-0.97 High vs. Very low: HR 0.48 95% CI 0.38-0.61
Dikken, 2013 (27) Dikken, 2012 (28) abs **Esophageal Cancer**	Patients with esophageal cancer who received surgery from 2004-2009. This study also included patients with gastric cancer surgeries.	Retrospective cohort from the cancer registries in the Netherlands and England and clinical audits in Denmark and Sweden. Compared mortality and survival by hospital volume. 2-year survival was analyzed by Cox regression adjusting for sex, age, morphology, stage, and clustering of	Volume cutoffs (annual): 1-10, 11-20, 21-30, 31-40, ≥41	2-year survival, 30-day mortality.	**Esophagectomies:** 10,854 total cases (# of cases NR by volume cutoff) *30-day mortality (10,854 cases):* 11-20 vs. 1-10: OR 0.82 95% CI 0.61-1.11 21-30 vs. 1-10: OR 0.68 95% CI 0.50-0.93 31-40 vs. 1-10: OR 0.58 95% CI 0.39-0.85 ≥41 vs. 1-10: OR 0.55 95% CI 0.42-0.72 *2-year mortality (3942 cases):* 11-20 vs. 1-10: HR 0.92 95% CI 0.78-1.08 21-30 vs. 1-10: HR 0.84 95% CI 0.63-1.11 31-40 vs. 1-10: HR 0.77 95% CI 0.63-0.94 ≥41 vs. 1-10: HR 0.79 95% CI 0.66-0.96

		patients within hospitals. Patients from England were excluded from the 2-year survival analysis as data on stage were not available.			
Ghaferi, 2011 (29) **Esophageal Cancer**	Patients aged 65 to 99 years who underwent esophagectomy in U.S. This study also included patients who underwent gastrectomy or pancreatecomy	Retrospective cohort from the Medicare Provider Analysis and Review files from 2005 to 2007 comparing hospital mortality between very low and very high volume hospitals. Logistic regression adjusted using patient age, sex, race, urgency of operation, and comorbidities.	Volume cutoffs (annual): Very low: 1-4 Very high: 15-102	Hospital mortality (defined as 30-day or in-hospital mortality), Complications, Failure to rescue (death in a patient with 1 or more complications)	Very LVH: 4625 cases Very HVH: 4213 cases *Hospital mortality* (very LVH vs. very HVH): Adjusted OR: 3.70 95% CI 2.74-4.98 *Complications* (very LVH vs. very HVH): Adjusted OR: 1.35 95% CI 1.11-1.65 *Failure to rescue* (very LVH vs. very HVH): Adjusted OR: 3.18 95% CI 2.39-4.22
Kozower, 2012 (30) **Esophageal Cancer**	Patients who underwent esophagectomy for esophageal cancer in 2007.	Retrospective cohort from the HCUP-NIS (U.S.) comparing inpatient mortality by hospital volume. Hierarchical generalized linear models, adjusted by patient age, gender, and comorbid disease: 3 models: 1) volume as linear effect; 2) volume as nonlinear effect, restricted cubic spline; 3) volume as nonlinear effect, quintiles.	Volume cutoffs (annual): 1, 2, 3, 4-7, 8-120	In-hospital mortality	**Esophagectomies:** 1210 discharge records representing 6248 esophagectomies in the weighted data set. ***Inpatient mortality:*** *Linear effect:* OR: 0.97 95% CI 0.88-1.08 *Non-linear, restricted cubic splines:* OR: 0.79 95% CI 0.48-1.28 *Non-linear, quintiles:* 1 vs. 8-120: OR 12.69 95% CI 0.54-299.72 2 vs. 8-120: OR 4.09 95% CI 0.15-114.57 3 vs. 8-120: OR 3.03 95% CI 0.05-201.15 4-7 vs. 8-120: OR 2.77 95% CI 0.10-73.54
LaPar, 2012 (31) **Esophageal Cancer**	Patients who underwent esophagectomy for esophageal cancer in 2008. This study also included pancreatic resection, abdominal aortic aneurysm repair, and coronary artery bypass grafting.	Retrospective cohort from the HCUP-NIS (U.S.) comparing inpatient mortality by hospital volume. Hierarchical generalized linear models, adjusted by patient age, gender, and comorbid disease: 3 models: 1) volume as linear effect; 2) volume using restricted cubic spline; 3) volume using quintiles.	Volume cutoffs: NR	In-hospital mortality	**Esophagectomies:** Weighted total of 4764 patients with esophagectomy. *In-hospital mortality:* Linear effect total: LR: 0.49; p=0.4839 Quintile total: LR: 0.41; p=0.9817 Spline total: LR: 1.73; p=0.6303
Reames, 2013 (32) abstract **Esophageal Cancer**	Patients who underwent an esophageal resection. This study also included: abdominal aortic aneurysm repair; aortic valve surgery, mitral valve surgery, coronary artery bypass, carotid endarterectomy, colon	Retrospective cohort study using National Medicare claims data from 1998 through 2008 to compare operative mortality by hospital volume. Multivariate logistic regression models adjusted by patient characteristics.	Volume cutoffs: Hospitals were grouped into quintiles of operative volume. Cutoffs were NR.	Operative mortality.	**Esophageal resection:** Operative mortality: 1998-1999: Adjusted OR: 2.42 95% CI 1.65-3.54 2007-2008: Adjusted OR: 2.58 95% CI 1.89-3.51

	resection, and pancreatic resection.				
Reidy, 2012 (33) abstract **Esophageal Cancer**	Patients who underwent minimally invasive esophagectomy at either one HVH or one LVH, but by the same surgical team.	Retrospective cohort study from 2009-2010 at two centres in the U.S. The methods of analysis were NR.	Volume cutoff (annual): HVH: NR LVH: NR	LOS, 30-day mortality.	HVH: 127 cases LVH: 37 cases *LOS (median):* HVH: 7 days vs. LVH: 7 days; p=0.525 *30-day mortality:* HVH: 1.57% vs. LVH: 0; p=1.000
Rosati, 2012 (34) abstract **Esophageal Cancer**	Patients who underwent esophagectomies from 2005-2011.	Retrospective cohort study from 2005-2011 using data from hospitals in the Lombardy Region in Italy comparing 30-day post-operative mortality and hospital stay between hospital volume categories. Logistic regression model used to estimate association between hospital volume and outcomes (adjusted using age, sex and comorbidity index).	Volume cutoff (2005-2011): High: ≥150 Medium: 50-149 Low: ≤49	Length of hospital stay, 30-day post-operative mortality.	High: 4 hospitals, cases NR Medium: 9 hospitals, cases NR Low: 98 hospitals, cases NR Total: 2801 cases *Length of hospital stay:* High: median 20 days Medium: median 25 days Low: median 25 days *30-day post-operative mortality:* High: 1.7% Medium: 2.6% Low: 5.7% Medium vs. Low: adjusted OR: 0.47 95% CI 0.28-0.78 High vs. Low: adjusted OR: 0.36 95% CI 0.20-0.53
Varghese, 2011 (35) **Esophageal Cancer**	Patients aged ≥18 years who underwent esophagectomy, esophagogastrectomy not otherwise specified, intrathoracic esophagogastrectomy, antesternal esophagogastrectomy, or partial gastrectomy with anastomosis to esophagus from 2000-2007 in Washington State, U.S.	Retrospective cohort from the Washington State Comprehensive Hospital Abstract Reporting System database (Veterans Affairs and U.S. Military hospitals) from 2000-2007. Compared LOS, prolonged LOS, and 90-day mortality by hospital volume category. Logistic regression models to examine relationship between hospital volume and binary outcomes. Adjusted for clustering at hospital level and by age, sex, Charlson index, indication for resection (benign vs. malignant), insurance status, and calendar year.	Volume cutoff (annual): Leapfrog group cutoff was used: HVH: ≥13 LVH: <13	Prolonged LOS (greater than 14 days), 90-day mortality.	**Esophageal resections:** HVH: 838 cases in 5 hospitals. LVH: 514 cases in 40 hospitals. *Prolonged LOS:* Adjusted OR: 0.55 95% CI 0.43-1.00 for HVH vs. LVH. *90-day mortality:* Adjusted OR: 0.50 95% CI 0.27-0.91 for HVH vs. LVH.
Massarweh, 2011 (36) **Esophageal Cancer**	Patients aged ≥18 years who underwent esophageal resection between January 1, 1994 and December 31, 2007 in Washington State, U.S. This study also included patients who underwent pancreatic	Retrospective cohort from the Washington State Comprehensive Hospital Abstract Reporting System (CHARS) database from 1994 to 2007. The cohort was split into 2 timeframes: 1) patients treated from	Volume cutoff (annual): Leapfrog group cutoff was used: HVH: ≥13 LVH: <13	30-day and 90-day mortality, 30-day postoperative complications.	**Esophageal resections:** ***1994-2000 Timeframe:*** HVH: 685 resections in 2-4 hospitals (# varied by year). LVH: 486 resections; # hospitals: NR. Adjusted 30-day mortality: HVH: 3.8% vs. LVH: 7.8%; p=0.03 Adjusted 90-day mortality:

	resection or abdominal aortic aneurysm repair.	1994-2000 where no Leapfrog threshold existed; or, 2) patients treated from 2001-2007 where the Leapfrog threshold existed. Compared mortality (30-day and 90-day) and postoperative complications for patients treated in hospitals meeting Leapfrog Group volume threshold for esophageal resections compared to patients treated in hospitals that did not meet the threshold.			HVH: 6.4% vs. LVH: 10.7%; p=0.004 Adjusted 30-day complications: HVH: 49.1% vs. LVH: 41.6%; p=0.04 ***2001-2007 Timeframe:*** HVH: 583 resections in 2-6 hospitals (# varied by year). LVH: 845 resections; # hospitals: NR. Adjusted 30-day mortality: HVH: 4.8% vs. LVH: 7.8%; p=0.30 Adjusted 90-day mortality: HVH: 6.3% vs. LVH: 9.8%; p=0.23 Adjusted 30-day complications: HVH: 44.2% vs. LVH: 43.4%; p=0.10
Hospital Other (e.g., Type of Centre)					
Sundaresan, 2013 (37) **Lung Cancer and Esophageal Cancer**	Patients who underwent thoracic surgeries for cancer (esophagectomy or pulmonary resection) from 2003-2011 in Ontario.	Retrospective cohort from the Canadian Institute for Health Information (CIHI) Discharge Abstract Database comparing 30-day mortality rates before (2004-2005) and after (2009-2011) regionalization of thoracic cancer surgical procedures. Upaired t test, $\propto$=0.05.	Regionalization: In 2004, 46 hospitals performed thoracic surgical oncology procedures. By late 2010, 15 hospitals performed thoracic surgical oncology procedures. Level I centre (n=13): 150 lung resections/year & 20 esophagectomy/year Level II centre (n=2): 20 lung resections/year & 7 esophagectomy/year	30-day mortality	**2004-2005:** *Lung resections:* 4 hospitals performed >150 /year; 1 hospital performed >100/year; 41 hospitals performed ≤100/year. *Esophagectomies:* 4 hospitals performed >20/year; 3 hospitals performed >10/year; 39 hospitals performed ≤10/year. **2010-2011:** *Lung resections:* 5 hospitals performed >150/year; 4 hospitals performed 100-150/year; 2 hospitals performed almost 100/year; 1 hospital (Level II) performed >50/year; 1 hospital (Level II) performed <50/year; 2 hospitals were NR. *Esophagectomies:* 5 hospitals performed >20/year; 8 hospitals performed ≥10/year; 2 hospitals were NR. **30-day mortality:** ***Esophagectomy:*** 2004-2005: 5.9% vs. 2009-2011: 5.8%; p=0.96 ***Lobectomy:*** 2004-2005: 2.2% vs. 2009-2011: 1.9%; p=0.37 ***Pneumonectomy:*** 2004-2005: 10.9% vs. 2009-2011: 5.6%; p=0.03
Bilimoria, 2010 (38) **Lung Cancer or Esophageal Cancer**	Patients who underwent surgical treatment for lung cancer or esophageal cancer in the U.S. from 2003-2005. This study also included bladder, breast, colon, gastric, liver, melanoma, ovarian, pancreas, prostate, rectal, renal,	Retrospective cohort from the National Cancer Database (U.S.) from 2003-2005 comparing 60-day perioperative mortality by hospital type. Cox proportional hazards regression was used to evaluate 60-day perioperative mortality by hospital	Hospital type: Specialized centres (SC): NCI-designated cancer centre and cancer site-specific hospitals in the highest procedure volume quintile (cutoffs NR).	60-day perioperative mortality	**Lung Cancer:** 77561 patients: SC: 23.5%; Other: 20.5%; CH: 56.0% 1350 hospitals: SC: 5.8%; Other: 16.1%; CH: 78.1% **60-day perioperative mortality:** ***High-risk patients (age ≥75 years or Charlson score ≥2):*** 61860 patients *Unadjusted rate:* SC: 3.7%* Other: 4.9%*

	thyroid, and uterine cancers.	type while adjusting for gender, age, race, stage of disease, Charlson score, patients' median zip-code income, and type of resection.	Other Academic Institutions (Other): Lower-volume, non-NCI-designated cancer centres. Community Hospitals (CH)		CH: 6.0%; *p<0.05 in comparison to CH *Adjusted HR:* SC vs. CH: 0.64 95% CI 0.58-0.70 Other vs. CH: 0.85 95% CI 0.78-0.93 ***Low risk patients (age<75 years or Charlson score <2):*** 15701 patients *Unadjusted rate:* SC: 1.6% Other: 2.3% CH: 2.3% *Adjusted HR:* SC vs. CH: 0.65 95% CI 0.42-1.01 Other vs. CH: 0.86 95% CI 0.58-1.26 **Esophageal Cancer:** 6155 patients: SC: 28.9%; Other: 28.0%; CH: 43.1% 928 hospitals: SC: 4.5%; Other: 22.0%; CH: 73.5% **60-day perioperative mortality:** ***High-risk patients (age ≥75 years or Charlson score ≥2):*** 2418 patients *Unadjusted rate:* SC: 6.2%* Other: 11.0% CH: 13.0% *p<0.05 in comparison to CH *Adjusted HR:* SC vs. CH: 0.48 95% CI 0.33-0.69 Other vs. CH: 0.87 95% CI 0.66-1.16 ***Low risk patients (age<75 years or Charlson score <2):*** 3737 patients *Unadjusted rate:* SC: 3.4%* Other: 6.5% CH: 7.3% *p<0.05 in comparison to CH *Adjusted HR:* SC vs. CH: 0.46 95% CI 0.32-0.67 Other vs. CH: 0.84 95% CI 0.62-1.14
Cheung, 2010 (39) **Esophageal Cancer**	Patients with esophageal cancer who received surgical treatment in the state of Florida between 1998-2002. This study also included patients with esophageal cancer treated with other modalities.	Retrospective cohort from the Florida Cancer Data System (FCDS) and the Agency for Health Care Administration datasets, comparing survival between teaching hospitals and non-teaching hospitals in the state of Florida. Kaplan-Meier survival curves compared using the log-rank test.	Hospital type: *Teaching:* Recognized as a teaching institution by the Association of American Medical Colleges (AAMC). *Non-teaching:* Not recognized by the AAMC.	Overall survival, 90-day mortality	*Esophageal resections:* Teaching: 201 cases Non-teaching: 770 cases *Median overall survival:* Teaching: 47.3 months vs. Non-teaching: 20.5 months; p<0.001. *90-day mortality:* Teaching: 4.1% vs. Non-teaching: 11.2%; p<0.001
Dikken, 2012 (40)	Patients with esophageal cancer who received an	Retrospective cohort from the Netherlands Cancer Registry	Hospital type:	3-month mortality, 3-year survival	*Esophagectomies:* UTH: 1132 cases NUTH: 7387 cases

Dikken, 2013 (41) abs **Esophageal Cancer**	esophagectomy from 1989-2009. This study also included patients with gastric cancer.	comparing 3-month mortality and 3-year survival by type of hospital. Cox regression adjusted for annual hospital volume, year of diagnosis, sex, age, SES, tumour stage, morphology, pre- and post-operative therapy and for clustering of deaths within hospitals.	UTH: university teaching hospital NUTH: non-university teaching hospital NUNTH: non-university, non teaching hospital.		NUNTH: 5702 cases *3-month mortality:* NUTH: 4.4% UTH: 2.5% NUNTH: 4.1% NUNTH vs. NUTH: HR 0.95 95% CI 0.80-1.13 UTH vs. NUTH: HR 0.56 95% CI 0.37-0.85 *3-year survival:* NUTH: 42% UTH: 46% NUNTH: 43% NUNTH vs. NUTH: HR 0.97 95% CI 0.89-1.06 UTH vs. NUTH: HR 0.87 95% CI 0.78-0.99
Merkow, 2013 (42) **Esophageal Cancer**	Patients who underwent esophageal resection between 2007-2011 in the U.S. This study also included patients who underwent colorectal or pancreatic surgeries for cancer.	Retrospective cohort from the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database. Compared outcomes between National Cancer Institute Cancer Centres (NCI-CC's) to non-NCI CC's. Risk-adjusted ORs were calculated by accounting for potential nonindependence of patients nested within hospitals and inflation in the false-positive rate because of multiple testing, reliability "shrinkage" adjustment by optimally combining information from the specific hospital, and the statistically estimated "average" hospital to get a best estimate of the hospital performance in terms of an OR (the odds at the hospital vs. the odds at the average hospital).	Hospital type: NCI-CC: National Cancer Institute Cancer Centre. Non-NCI-CC: non-National Cancer Institute Cancer Centre.	30-day mortality, 30-day morbidity, prolonged LOS.	***Esophageal Resections:*** NCI-CC: 1596 resections. Non-NCI-CC: 3208 resections. Total # hospitals: 275 *30-day mortality:* NCI-CC: 2.4% vs. non-NCI-CC: 3.7% Unadjusted OR: 0.79; 95% CI 0.56-1.10 Adjusted OR: 0.88; 95% CI 0.55-1.41 *30-day morbidity:* NCI-CC: 25.7% vs. non-NCI-CC: 28.5% Unadjusted OR: 0.96; 95% CI 0.83-1.10 Adjusted OR: 0.86; 95% CI 0.70-1.05 *Prolonged LOS:* NCI-CC: 19.1% vs. non-NCI-CC: 21.2% Unadjusted OR: 0.86; 95% CI 0.74-0.99 Adjusted OR: 0.69; 95% CI 0.51-0.92
Surgeon volume					
Boudourakis 2009 (43) **Esophageal Cancer and Lung Cancer**	Patients ≥18, esophaectomy or lung lobectomy with primary diagnosis of cancer	Cross-sectional analysis, comparing 1999 and 2005 discharge information from HCUP-NIS administrative database Chi-square, multivariable linear regression models for LOS and mortality adjusted by patient	Surgeon volume ***Volume cutoff:*** *Lung Cancer:* Low: ≤4 High: ≥12 *Esophageal Cancer:* Low: ≤22 High: ≥50	Inpatient mortality, LOS	**Esophagectomy:** *# of patients:* 1999: 221 2005: 318 ***Unadjusted outcomes*** *Mortality (%)* 1999: HV: 0.0, LV: 6.8, p<0.05 2005: HV: 0.6, LV: 8.8, p<0.05 *LOS (mean days)* 1999: HV 11.2, LV: 17.4, p<0.001

		and provider characteristics.			2005: HV 12.5, LV: 18.5, p<0.05 **Lung Lobectomy:** *# of patients:* 1999: 3721 2005: 4053 ***Unadjusted outcomes*** *Mortality (%)* 1999: HV: 2.5, LV: 3.9, p=ns 2005: HV: 1.4, LV: 3.3, p<0.05 *LOS (mean days)* 1999: HV: 7.1, LV: 9.1, p<0.001 2005: HV: 6.4, LV: 8.9, p<0.001
Surgeon other (e.g., Training)					
Ellis, 2011 (44) **Lung Cancer**	Patients with lung cancer who received wedge resection, segmentectomy, lobectomy, or pneumonectomy.	Retrospective cohort from the Nationwide Inpatient Sample database (U.S.) from 1998 to 2007. Multivariate analysis using binary logistic regression models.	Surgeon type: *General thoracic surgeon (GTS):* >75% of procedures were general thoracic operations and ≤10% of procedures were cardiac operations. *Cardiac surgeon (CS):* >10% of procedures were cardiac operations. *General surgeon (GS):* <75% of procedures were general thoracic operations and <10% of procedures were cardiac operations.	In-hospital mortality, post-op complications.	GS: 118,843 cases GTS: 18,284 cases CS: 85,106 cases ***In-hospital Mortality:*** GS unadjusted rate: 4.0% GTS unadjusted rate: 2.3% CS unadjusted rate: 3.4% GS vs. GTS: OR 1.55, 95% CI 1.20-2.01, p<0.001 ***Post-op Complications:*** GS: 33.5% GTS: 28.5% CS: 31.3% GS vs. GTS: OR 1.16, 95% CI 1.00-1.35, p=0.049
Freeman, 2013 (45) **Lung Cancer**	Patients with NSCLC who received a lobectomy.	Retrospective cohort from the Premier inpatient database (U.S.) from 2005-2009. Data collected from hospitals with at least 50 lobectomies for NSCLC during 2005-2009. Multiple logistic regression analysis adjusted for clustering or nesting at the hospital level and adjustment for patient age and Charlson comorbidity index score.	Surgeon type: *General surgeon (GS) vs. thoracic surgeon (TS):* classification based on surgeons' national provider numbers and board certification status.	Operative mortality (death after surgery but before discharge from hospital or within 30-days of surgery); morbidity.	Data from 54 hospitals in 31 states: GS: 2823 lobectomies by 46 GS TS: 3653 lobectomies by 29 TS ***Operative mortality:*** GS: 7% vs. TS: 2%; p<0.0001 Adjusted (age, Charlson index) OR: 0.37 95% CI 0.13-0.59, p<0.0001, for TS vs. GS. Adjusted (hospital and surgeon volume) OR: 0.60 95% CI 0.53-0.72, p<0.0001, for TS vs. GS. ***Morbidity:*** GS: 11% vs. TS: 4%; p<0.0001
Gopaldas, 2013 (46) Gopaldas, 2011 (47) abs	Patients who underwent esophagectomy	Retrospective cohort from the Nationwide Inpatient Sample (U.S.) from 1998 to 2008 comparing mortality, complications, and	Surgeon type: *Thoracic surgeon (TS), or Cardiac surgeon (CS), or General surgeon*	In-hospital mortality, failure to rescue	Control: 15,728 cases TS: 3026 cases CS: 688 cases GS: 4086 cases ***In-hospital mortality:***

Esophageal Cancer		failure to rescue between surgeon types. Wald chi-squared test to assess surgeon type and outcomes and multivariable logistic regression model.	*(GS):* had a 65% or more case mix in that specialty. If less than 65%, they were *unclassified and used as a control group*.		*Unadjusted rates:* Control: 8.2% TS: 4.7% CS: 13.7% GS: 6.7% *Adjusted OR:* TS vs. control: 1.11, p=0.55 CS vs. control: 1.06, p=0.82 GS vs. control: 1.87, p=0.04 ***Failure to rescue:*** *Unadjusted rates:* Control: 7.6% TS: 3.7% CS: 12.9% GS: 6.4% *Adjusted OR:* TS vs. control: 1.08, p=0.65 CS vs. control: 0.90, p=0.72 GS vs. control: 1.95, p=0.03
Leigh, 2009 (48) **Esophageal Cancer**	Patients who underwent esophagectomy for esophageal cancer from April 1, 1998 to March 31, 2003.	Retrospective cohort identified from the Hospital Episode Statistics database (U.K.) from April 1, 1998 to March 31, 2003 comparing mortality by hospital volume and surgeon specialty. Differences in mortality between specialties and between hospital volume categories were tested using chi-squared tests. Multivariable logistic regression adjusted by age, sex and SES-deprivation score.	**Surgeon specialties:** General surgeon (GS) vs. Cardiothoracic surgeon (CTS) (no definitions reported) **Hospital volume cutoff (annual):** HVH: ≥100 LVH: <100	30-day and 90-day mortality.	**Surgeon specialty:** GS: 6568 cases CTS: 2466 cases *30-day mortality:* GS: 9.0% vs. CTS: 6.1%; p<0.05 OR: 1.52 95% CI 1.27-1.83 Adjusted OR: 1.62 95% CI 1.34-1.96 *90-day mortality:* GS: 13.0% vs. CTS: 10.3%; p<0.05 OR: 1.31 95% CI 1.13-1.51 Adjusted OR: 1.38 95% CI 1.18-1.61 **Hospital volume:** HVH: 3791 cases LVH: 5243 cases *30-day mortality:* LVH: 9.6% vs. HVH: 6.3%; p<0.05 OR: 1.58 95% CI 1.35-1.86 Adjusted OR: 1.62 95% CI 1.38-1.91 *90-day mortality:* LVH: 14.0% vs. HVH: 9.8%; p<0.05 OR: 1.51 95% CI 1.32-1.72 Adjusted OR: 1.55 95% CI 1.35-1.77
Smith, 2008 (49) **Esophageal Cancer**	Patients who underwent esophagectomy from 2003 to 2007 in the U.S.	Retrospective cohort from the University HealthSystem Consortium Clinical Database from 2003 to 2007 comparing LOS, perioperative complications, and in-hospital mortality by surgeon specialty. Continuous variables were analyzed using 2-sample t-tests and categorical variables by Pearson chi-squared tests.	**Surgeon specialties:** General surgeon (GS): general, vascular, and oncologic surgical training and certification labels. Cardiothoracic surgeon (CTS): cardiothoracic and/or thoracic surgery training and certification labels.	Perioperative complications, LOS (ICU and hospital), and in-hospital mortality.	2657 total esophagectomies at 93 centres GS: 1079 cases CTS: 1578 cases *Perioperative complications:* GS: 55% vs. CTS: 52%; p=0.11 *LOS-ICU (mean):* GS: 8.4 days vs. CTS: 9.7 days; p=0.29 *LOS-hospital (mean):* GS: 16.6 days vs. CTS: 16.9 days; p=0.80 *In-hospital mortality:* GS: 3.6% vs. CTS: 2.9%; p=0.31
Hospital and Surgeon Volume					

Chang, 2012 (50) **Lung Cancer**	Patients with lung cancer who received surgical treatment with or without adjuvant therapy in 2002. Also included other surgeries for other cancers.	Retrospective cohort from the NHI Research Database in Taiwan using data from 2002 to 2006. Kaplan-Meier survival curves compared using log-rank test; Cox proportional regression model to compared combined effect of surgeon and hospital volume on survival rates with adjustment for patient comorbidities, geographic location, type of residence, and treatment modalities.	Hospital volume Cutoffs: Low: <62 High: ≥62 Surgeon volume Cutoffs: Low: <6 High: ≥6	5-year survival	LVH+LVS: 155 cases LVH+HVS: 275 cases HVH+LVS: 46 cases HVH+HVS: 179 cases *Unadjusted 5-year survival:* LVH+LVS: 30.3% LVH+HVS: 44.7% HVH+LVS: 43.5% HVH+HVS: 53.1% *Adjusted 5-year survival:* HVH+HVS: 50.2% vs. LVH+LVS: 39.5%, p<0.001, adjusted OR 1.67, 95% CI 1.02-2.73 Authors reported statistically significant differences in 5-year survival for HVH vs. LVH (p=0.001) and for HVS vs. LVS (p<0.001) in favour of high volume groups; however no further data were reported for these comparisons. *Multivariate regression analysis:* HVH+LVS vs. HVH+HVS: HR 1.33, 95% CI 0.85-2.08 LVH+HVS vs. HVH+HVS: HR 1.10, 95% CI 0.83-1.46 LVH+LVS vs. HVH+HVS: HR 1.82, 95% CI 1.35-2.46
Derogar, 2013 (51) **Esophageal Cancer**	Patients with esophageal cancer who had an esophagectomy from January 1, 1987 to December 31, 2005.	Retrospective cohort identified from the Swedish Cancer Registry. Multivariate parametric analysis adjusted for age, sex, Charlson comorbidity index, tumour stage at time of surgery, histological type of tumour, neoadjuvant therapy, and calendar period. Note: a subpopulation of this study was included in a study reported by Rouvelas et al (52). That study was included in the systematic reviews by Rouvelas et al (9), Gruen et al (3), and Wouters et al (2).	**Hospital volume** Low: ≤8 Medium: 9-16 High: ≥17 **Surgeon volume** *Annual:* Low: ≤4 Medium: 5-9 High: ≥10 *Cumulative:* Low: ≤11 Medium: 12-32 High: ≥33	Overall mortality	Total of 1,335 esophagectomies. **Hospital volume:** High: 299 cases Medium: 310 cases Low: 726 cases *Overall mortality multivariate analysis:* Med vs. Low: HR 0.96 95% CI 0.82-1.11 High vs. Low: HR 0.84 95% CI 0.72-0.98 HR 0.93 95% CI 0.77-1.13[B] **Annual surgeon volume:** High: 300 cases Medium: 355 cases Low: 680 cases *Overall mortality multivariate analysis:* Med vs. Low: HR 0.82 95% CI 0.70-0.96[C] HR 0.82 95% CI 0.70-0.97[D] High vs. Low: HR 0.82 95% CI 0.69-0.99[C] HR 0.85 95% CI 0.68-1.06[D] **Cumulative surgeon volume:** High: 330 cases Medium: 319 cases Low: 686 cases *Overall mortality multivariate analysis:* Med vs. Low: HR 1.00 95% CI 0.85-1.17[E] High vs. Low: HR 0.97 95% CI 0.80-1.17[E]
Other (Physical Resources, Collaborating Services, Human Resources, etc)					
Yasunaga, 2012 (53) **Lung Cancer and Esophageal Cancer**	Patients who underwent lung lobectomy (but not pneumonectomy) for lung cancer or esophagectomy for	Retrospective cohort using data from the Diagnosis Procedure Combination database and the Survey of Medical Institutions data from the Ministry	***Physician to bed ratio (PBR):*** Median PBR 19.7 physicians/100 beds Categories: Low PBR: <19.7/100 High PBR: ≥19.7/100	Postoperative complications, inhospital mortality, failure to rescue (proportion of inhospital deaths	**Esophagectomy:** N=3917 *Failure to rescue:* Group A: 21.8% Group B: 18.7% Group C: 10.9%

	esophageal cancer from 2007-2008. This study also included gastrectomy for gastric cancer, colorectal cancer surgery, hepatectomy for hepatic cancer, and pancreatectomy for pancreatic cancer.	of Health, Labour and Welfare of Japan from 2007-2008. Compared postoperative complications, inhospital mortality and failure to rescue by the physician to bed ratio and the nurse to bed ratio. Multivariate analyses to model outcomes by age, sex, Charlson comorbidity index, hospital volume and physician/nurse staffing using multi-level logistic regression. $\propto$=0.05	***Nurse to bed ratio (NBR):*** Median NBR: 77.0 nurses/100 beds Categories: Low NBR: <77.0/100 High NBR: ≥77.0/100 ***PBR and NBR were combined into one of four possible categories for analysis:*** *Group A:* Low PBR, low NBR *Group B:* Low PBR, high NBR *Group C:* High PBR, low NBR *Group D:* High PBR, high NBR ***Hospital volume categories (used to model outcomes):*** *Esophagectomies:* Low: ≤9 Medium: 10-26 High: ≥27 *Lung lobectomies:* Low: ≤51 Medium: 52-106 High: ≥107	among those who had experienced a postoperative complication). Only data on failure to rescue were reported for each type of surgery separately.	Group D: 13.8% P=0.001 **Lung lobectomy:** N=21639 *Failure to rescue:* Group A: 15.3% Group B: 12.9% Group C: 7.9% Group D: 5.9% P<0.001
Ball, 2013 (54) abstract **Esophageal Cancer**	Multi-disciplinary, goal-directed peri-operative management plan for patients having esophagectomy.	Doncaster Royal Infirmary, UK. Retrospective comparison of 2006-2009 cohort (before implementation of management plan) to 2010-2011 cohort (after implementation of management plan)	Before-and-after implementation of multi-disciplinary management plan.	In-hospital mortality, morbidity.	2006-2009 cohort: 51 patients In hospital mortality: 21% 8 patients extubated at end of surgery. 1 patient mobilized on first post-op day. Median critical care stay, 8 days. 2010 to 2011 cohort: 29 patients In hospital mortality: 0% No statistical comparisons were reported.
Brooke, 2012 (55) **Esophageal Cancer**	Adherence to Leapfrog Group and National Quality Forum (NQF) safe practices.	1,960 urban and rural hospitals in 41 states in the US.	Cross-sectional study comparing hospitals that fully met the NQF Safe Practices (Full) to those that partially met them (Partial). (the Safe Practices are reported in the full publication)	In-hospital/30-day mortality.	# of esophageal resections: Full NQF compliance: 1,974 cases Partial NQF compliance: 1,357 cases Mortality: Risk adjusted OR: 0.54 (95% CI 0.39-0.74) for full NQF compliance compared to partial. Complications: Full: 28.3%, Partial: 25.7%, p=NR
Kothari, 2010 (56) abstract **Esophageal Cancer**	Patients who underwent esophagectomy three years pre- and post-adoption of an Acuity Adaptable Care Unit (AACU).	Retrospective study comparing length of stay, 30-day mortality, and post-op complications for a 3-year period before implementation of an AACU to the 3-year	Before and after implementation of an AACU.	LOS, 30-day mortality, post-op complications.	Pre-AACU: 115 patients AACU: 119 patients *LOS:* Pre-AACU: 9d vs. AACU: 8d; p=0.21 *30-day mortality:* Pre-AACU: 0% vs. AACU: 1.6%; p=0.50

		period after implementation (U.S.). Kruskal-Wallis test to assess differences across eras.			*Post-op complications:* Pre-AACU: 58.3% vs. AACU: 51.3%; p=0.30
Preston, 2012 (57) abstract **Esophageal Cancer**	Patients who underwent esophagectomy pre- and post-implementation of a standardized postoperative care pathway (SPCP).	Retrospective study of patients from the Royal Surrey County Hospital (RSCH), U.K., comparing complications, ICU stay, and hospital stay between patients pre-SPCP and post-SPCP as well as to a control group from 2009-2001 from the Virginia Mason Medical Centre (VMMC), Seattle U.S., where the same SPCP had been in use since 1991.	Comparison of SCPC patients to pre-SPCP patients and SCPC patients at U.K. hospital to patients in the same SPCP at the U.S. hospital.	Complications, ICU stay, hospital stay.	RSCH pre-SPCP: 12 patients RSCH SPCP: 12 patients VMMC SPCP: 74 patients *Complications:* RSCH pre-SPCP: 75% vs. RSCH SPCP: 33.3%; p<0.05 RSCH SPCP: 33.3% vs. VMMC SPCP: 47.3%; p=0.53 *ICU stay:* RSCH pre-SPCP: 4 days vs. RSCH SPCP: 3 days; p<0.05 RSCH SPCP: 3 days vs. VMMC SPCP: 1 day; p<0.05 *Hospital stay:* RSCH pre-SPCP: 17 days vs. RSCH SPCP: 7 days; p<0.05 RSCH SPCP: 7 days vs. VMMC SPCP: 8 days; p=0.25

Notes: HCUP-NIS: Health care utilization project national inpatient sample; HR: hazard ratio; HVH: high volume hospital; HVS=high volume surgeon; LOS: length of stay; LVH: low volume hospital; LVS=low volume surgeon; NCDB: National Cancer Database; NHI=National Health Insurance; NIS: Nationwide Inpatient Sample of the Healthcare Cost and Utilization Project; OR=odds ratio; SD=standard deviation; SES: socioeconomic status.

[A]Multidisciplinary plan included: two-consultant operations, laprascopic completion of abdominal component of surgery, limiting number of consulting anesthetists, early extubation after surgery, optimization of analgesia, use of epidural anesthesia, early physiotherapy input, early mobilization, daily senior review, early nutritional support via TPN.

[B]In addition to adjustments defined in Methods column, adjustment was also made for annual and cumulative surgeon volume.

[C]In addition to adjustments defined in Methods column, adjustment was also made for cumulative surgeon volume.

[D]In addition to adjustments defined in Methods column, adjustment was also made for cumulative surgeon volume and annual hospital volume.

[E]In addition to adjustments defined in Methods column, adjustment was also made for annual surgeon volume.

See Appendix 1 for a list of identified studies that were included in at least one of the systematic reviews in Table 1. Please note that these studies were not included in Table 2.

Clinical Expert Interest Declaration:

The clinical expert, Dr. Sudhir Sundaresan, declared that he had no conflicts of interest.

Instructions. Instructions. For each document, please respond YES or NO to all the questions below. Provide an explanation of each answer as necessary.

1. Does any of the newly identified evidence, on initial review, contradict the current recommendations, such that the current recommendations may cause harm or lead to unnecessary or improper treatment if followed?	NO.
2. On initial review, a. Does the newly identified evidence support the existing recommendations?	2.a.) YES. 2.b.) YES.

b. Do the current recommendations cover all relevant subjects addressed by the evidence, such that no new recommendations are necessary?	
3. Is there a good reason (e.g., new stronger evidence will be published soon, changes to current recommendations are trivial or address very limited situations) to postpone updating the guideline? Answer Yes or No, and explain if necessary:	NO.
4. Do the PEBC and the DSG/GDG responsible for this document have the resources available to write a full update of this document within the next year?	YES.

Review Outcome	**Opinion of Clinical Reviewer:** The recommendations are valid and can be endorsed as is; however, the clinical reviewer feels that there may be merit in updating and rewriting the guideline as the evidence base is larger now and some recommendations could be stronger.
DSG/GDG Approval Date	March 4, 2015
DSG/GDG Commentary	The 2015 Expert Panel on Thoracic Surgical Oncology reviewed the recommendation of the clinical reviewer to endorse and the new literature summarized in the review tool. All 17 members of the panel agreed that the 2005 recommendations could be endorsed, that minor changes to the wording of the recommendations for clarification were reasonable (these are noted above). It was noted in discussion that the additional literature is still insufficient to make specific recommendations regarding target surgical volumes but that the original 2005 consensus recommendations based on the expert opinion of the original panel were reasonable and should continue to guide practice in Ontario. Since 2005, several guidance documents have been developed by CCO that are relevant to the Thoracic Standards. An updated inventory of these documents has been added to the Recommendations Section 1, and should be used to guide practice.

REFERENCES

1. Pieper D, Mathes T, Neugebauer E, Eikermann M. State of evidence on the relationship between high-volume hospitals and outcomes in surgery: a systematic review of systematic reviews. J Am Coll Surg. 2013 May;216(5):1015-25.e18.
2. Wouters MW, Krijnen P, Le Cessie S, Gooiker GA, Guicherit OR, Marinelli AW, et al. Volume- or outcome-based referral to improve quality of care for esophageal cancer surgery in The Netherlands. J Surg Oncol. 2009 Jun 15;99(8):481-7.
3. Gruen RL, Pitt V, Green S, Parkhill A, Campbell D, Jolley D. The effect of provider case volume on cancer mortality: Systematic review and meta-analysis. CA Cancer Journal for Clinicians. 2009 May/June;59(3):192-211.
4. von Meyenfeldt EM, Gooiker GA, van Gijn W, Post PN, van de Velde CJ, Tollenaar RA, et al. The relationship between volume or surgeon specialty and outcome in the surgical treatment of lung cancer: a systematic review and meta-analysis. Journal of Thoracic Oncology: Official Publication of the International Association for the Study of Lung Cancer. 2012 Jul;7(7):1170-8.
5. Markar SR, Karthikesalingam A, Thrumurthy S, Low DE. Volume-outcome relationship in surgery for esophageal malignancy: systematic review and meta-analysis 2000-2011. J Gastrointest Surg. 2012 May;16(5):1055-63.
6. Centre for Reviews and Dissemination. Volume-outcome relationship in surgery for esophageal malignancy: systematic review and meta-analysis 2000-2011 (Structured abstract). Database of Abstracts of Reviews of Effects. 2013(4).
7. Wouters MW, Gooiker GA, van Sandick JW, Tollenaar RA. The volume-outcome relation in the surgical treatment of esophageal cancer: a systematic review and meta-analysis. Cancer. 2012 Apr 1;118(7):1754-63.
8. Von Meyenfeldt EM, Gooiker GA, Van Gijn W, Post PN, Van De Velde CJH, Tollenaar RAEM, et al. The relationship between volume or surgeon specialty and outcome in the surgical treatment of lung cancer - A systematic review and meta-analysis. Eur J Cancer. 2011 September;47:S263-S4.
9. Rouvelas I, Lagergren J. The impact of volume on outcomes after oesophageal cancer surgery. ANZ J Surg. 2010 Sep;80(9):634-41.
10. Killeen SD, O'Sullivan MJ, Coffey JC, Kirwan WO, Redmond HP. Provider volume and outcomes for oncological procedures. Br J Surg. 2005 April;92(4):389-402.
11. Metzger R, Bollschweiler E, Vallbohmer D, Maish M, DeMeester TR, Holscher AH. High volume centers for esophagectomy: what is the number needed to achieve low postoperative mortality? Dis Esophagus. 2004;17(4):310-4.
12. Croke JM, El-Sayed S. Multidisciplinary management of cancer patients: Chasing a shadow or real value? an overview of the literature. Current Oncology. 2012;19(4):e232-e8.
13. Coory M, Gkolia P, Yang IA, Bowman RV, Fong KM. Systematic review of multidisciplinary teams in the management of lung cancer. Lung Cancer. 2008 Apr;60(1):14-21.
14. Finley CJ, Bendzsak A, Tomlinson G, Keshavjee S, Urbach DR, Darling GE. The effect of regionalization on outcome in pulmonary lobectomy: a Canadian national study. J Thorac Cardiovasc Surg. 2010 Oct;140(4):757-63.
15. Kozower BD, Stukenborg GJ. The relationship between hospital lung cancer resection volume and patient mortality risk. Ann Surg. 2011 Dec;254(6):1032-7.
16. Luchtenborg M, Riaz SP, Coupland VH, Lim E, Jakobsen E, Krasnik M, et al. High procedure volume is strongly associated with improved survival after lung cancer surgery. J Clin Oncol. 2013 Sep 1;31(25):3141-6.
17. Otake H, Yasunaga H, Horiguchi H, Matsutani N, Matsuda S, Ohe K. Impact of hospital volume on chest tube duration, length of stay, and mortality after lobectomy. Ann Thorac Surg. 2011 Sep;92(3):1069-74.

18. Park HS, Detterbeck FC, Boffa DJ, Kim AW. Impact of hospital volume of thoracoscopic lobectomy on primary lung cancer outcomes. Ann Thorac Surg. 2012 Feb;93(2):372-9.
19. Park HS, Detterbeck FC, Boffa DJ, Kim AW. Impact of hospital operative volume of videoassisted thoracoscopic lobectomy on perioperative outcomes for primary lung cancer. J Thorac Oncol. 2011 June;6(6 Suppl 2):S598S-9, Abs MO14.02.
20. Smithers M, Zarate D, Harden H, Colquist S, Walpole E. The volume-outcome relationship in cancer surgery - do rural patients have a choice? Asia Pac J Clin Oncol. 2013 November;9:87-8.
21. Yun YH, Kim YA, Min YH, Park S, Won YJ, Kim DY, et al. The influence of hospital volume and surgical treatment delay on long-term survival after cancer surgery. Ann Oncol. 2012 Oct;23(10):2731-7.
22. Learn PA, Bach PB. A decade of mortality reductions in major oncologic surgery: the impact of centralization and quality improvement. Med Care. 2010 Dec;48(12):1041-9.
23. Allareddy V, Ward MM, Allareddy V, Konety BR. Effect of meeting Leapfrog volume thresholds on complication rates following complex surgical procedures. Ann Surg. 2010 Feb;251(2):377-83.
24. Finley CJ, Jacks L, Keshavjee S, Darling G. The effect of regionalization on outcome in esophagectomy: a Canadian national study. Ann Thorac Surg. 2011 Aug;92(2):485-90; discussion 90.
25. Dikken JL, Dassen AE, Lemmens VE, Putter H, Krijnen P, van der Geest L, et al. Effect of hospital volume on postoperative mortality and survival after oesophageal and gastric cancer surgery in the Netherlands between 1989 and 2009. Eur J Cancer. 2012 May;48(7):1004-13.
26. Dikken JL, Dassen AE, Lemmens VEP, Van Der Geest L, Bosscha K, Verheij M, et al. Centralization for esophagectomy but not for gastrectomy in the netherlands, the relation between annual hospital volume, postoperative mortality and long term survival. Eur J Cancer. 2011 September;47:S443.
27. Dikken JL, van Sandick JW, Allum WH, Johansson J, Jensen LS, Putter H, et al. Differences in outcomes of oesophageal and gastric cancer surgery across Europe. Br J Surg. 2013 Jan;100(1):83-94.
28. Dikken J, Van Sandick JW, Allum WH, Johansson J, Jensen LS, Putter H, et al. Differences in outcomes and hospital volumes of oesophagogastric cancer surgery across Europe. Eur J Surg Oncol. 2012 September;38 (9):765-6.
29. Ghaferi AA, Birkmeyer JD, Dimick JB. Hospital volume and failure to rescue with high-risk surgery. Med Care. 2011 Dec;49(12):1076-81.
30. Kozower BD, Stukenborg GJ. Hospital esophageal cancer resection volume does not predict patient mortality risk. Ann Thorac Surg. 2012 May;93(5):1690-6; discussion 6-8.
31. LaPar DJ, Kron IL, Jones DR, Stukenborg GJ, Kozower BD. Hospital procedure volume should not be used as a measure of surgical quality. Ann Surg. 2012 Oct;256(4):606-15.
32. Reames BN, Ghaferi AA, Dimick JB. Hospital volume and operative mortality in the modern era. J Surg Res. 2013 February;179(2):227, Abs 22.9.
33. Reidy M, K SN, Luketich J, Awais O, Stahlfeld K. Can a high volume surgeon open a new minimally invasive esophagectomy program without compromising outcomes? Dis Esophagus. 2012 October;25:98A.
34. Rosati R, Bersani M, Russo A, Massaron S, Melis A, Fumagalli U. Italian experience-The experience in the Region of Lombardy. Dis Esophagus. 2012 October;25:22A.
35. Varghese TK, Jr., Wood DE, Farjah F, Oelschlager BK, Symons RG, MacLeod KE, et al. Variation in esophagectomy outcomes in hospitals meeting Leapfrog volume outcome standards. Ann Thorac Surg. 2011 Apr;91(4):1003-9; discussion 9-10.

36. Massarweh NN, Flum DR, Symons RG, Varghese TK, Pellegrini CA. A critical evaluation of the impact of Leapfrog's evidence-based hospital referral. J Am Coll Surg. 2011 Feb;212(2):150-9.e1.
37. Sundaresan S, McLeod R, Irish J, Burns J, Hunter A, Meertens E, et al. Early results after regionalization of thoracic surgical practice in a single-payer system. Ann Thorac Surg. 2013 Feb;95(2):472-8; discussion 8-9.
38. Bilimoria KY, Bentrem DJ, Talamonti MS, Stewart AK, Winchester DP, Ko CY. Risk-based selective referral for cancer surgery: a potential strategy to improve perioperative outcomes. Ann Surg. 2010 Apr;251(4):708-16.
39. Cheung MC, Koniaris LG, Yang R, Zhuge Y, Mackinnon JA, Byrne MM, et al. Do all patients with carcinoma of the esophagus benefit from treatment at teaching facilities? J Surg Oncol. 2010 Jul 1;102(1):18-26.
40. Dikken JL, Wouters MW, Lemmens VE, Putter H, van der Geest LG, Verheij M, et al. Influence of hospital type on outcomes after oesophageal and gastric cancer surgery. Br J Surg. 2012 Jul;99(7):954-63.
41. Dikken JL, Henneman D, Putter H, Lemmens VEPP, Van Der Geest LG, Van Hillegersberg R, et al. Centralization of esophagectomy for cancer: How far should we go? Eur J Cancer. 2013 September;49:S576.
42. Merkow RP, Bentrem DJ, Chung JW, Paruch JL, Ko CY, Bilimoria KY. Differences in patients, surgical complexity, and outcomes after cancer surgery at National Cancer Institute-designated cancer centers compared to other hospitals. Med Care. 2013 Jul;51(7):606-13.
43. Boudourakis LD, Wang TS, Roman SA, Desai R, Sosa JA. Evolution of the surgeon-volume, patient-outcome relationship.[Erratum appears in Ann Surg. 2009 Dec;250(6):1046]. Ann Surg. 2009 Jul;250(1):159-65.
44. Ellis MC, Diggs BS, Vetto JT, Schipper PH. Intraoperative oncologic staging and outcomes for lung cancer resection vary by surgeon specialty. Ann Thorac Surg. 2011 Dec;92(6):1958-63; discussion 63-4.
45. Freeman RK, Dilts JR, Ascioti AJ, Giannini T, Mahidhara RJ. A comparison of quality and cost indicators by surgical specialty for lobectomy of the lung. J Thorac Cardiovasc Surg. 2013 Jan;145(1):68-73; discussion -4.
46. Gopaldas RR, Bhamidipati CM, Dao TK, Markley JG. Impact of surgeon demographics and technique on outcomes after esophageal resections: a nationwide study. Ann Thorac Surg. 2013 Mar;95(3):1064-9.
47. Gopaldas RR, Dao TK, Markley JG. The impact of surgeon specialty case-mix, volume and surgical technique on failure to rescue, morbidity and mortality following esophageal resections: A 11-year population based study. J Am Coll Surg. 2011 September;213(3 Suppl):S41-S2.
48. Leigh Y, Goldacre M, McCulloch P. Surgical specialty, surgical unit volume and mortality after oesophageal cancer surgery. Eur J Surg Oncol. 2009 Aug;35(8):820-5.
49. Smith BR, Hinojosa MW, Reavis KM, Nguyen NT. Outcomes of esophagectomy according to surgeon's training: general vs. thoracic. J Gastrointest Surg. 2008 Nov;12(11):1907-11.
50. Chang CM, Huang KY, Hsu TW, Su YC, Yang WZ, Chen TC, et al. Multivariate analyses to assess the effects of surgeon and hospital volume on cancer survival rates: a nationwide population-based study in Taiwan. PLoS ONE [Electronic Resource]. 2012;7(7):e40590.
51. Derogar M, Sadr-Azodi O, Johar A, Lagergren P, Lagergren J. Hospital and surgeon volume in relation to survival after esophageal cancer surgery in a population-based study. J Clin Oncol. 2013 Feb 10;31(5):551-7.
52. Rouvelas I, Lindblad M, Zeng W, Viklund P, Ye W, Lagergren J. Impact of hospital volume on long-term survival after esophageal cancer surgery. Arch Surg. 2007 Feb;142(2):113-7.

53. Yasunaga H, Hashimoto H, Horiguchi H, Miyata H, Matsuda S. Variation in cancer surgical outcomes associated with physician and nurse staffing: a retrospective observational study using the Japanese Diagnosis Procedure Combination Database. BMC Health Serv Res. 2012;12:129.
54. Ball C, Seidel J, Jacob G, Kelty CJ, Saha AK. Improvements in outcomes after surgery for oesophageal cancer in a non-teaching hospital setting. Surgical Endoscopy and Other Interventional Techniques. 2013 April;27:S489.
55. Brooke BS, Dominici F, Pronovost PJ, Makary MA, Schneider E, Pawlik TM. Variations in surgical outcomes associated with hospital compliance with safety practices. Surgery. 2012 May;151(5):651-9.
56. Kothari A, Hennon M, Bretl T, Munoz-Del-Rio A, Weigel T. An acuity adaptable patient care unit does not change surgical outcomes in patients undergoing esophagectomy. Ann Surg Oncol. 2010 February;17:S123.
57. Preston S, Markar SR, Baker C, Soon Y, Singh S, Low D. Translocation of multidisciplinary standardised clinical pathways between hospitals and health systems is feasible and can produce immediate improvement in perioperative outcomes of surgical treatment of oesophageal cancer. Gut. 2012 July;61:A54-A5.

APPENDIX 1. EBS #17-1: Thoracic Surgical Oncology Standards. Screening of Literature Search Results

Introduction

Cancer Care Ontario (CCO) asked the PEBC to update evidence-based series (EBS) #17-1 as the last literature search was conducted more than 10 years ago. The original literature search could not be found and the PEBC had to recreate a search strategy. This new strategy returned 19,263 non-duplicate citations identified from the databases of MEDLINE via OVID (2004 to November Week 3, 2013 [Dec 23, 2013]), EMBASE via OVID (2004 to 2013 Week 51 [Dec 23, 2013]) and the Cochrane Library via OVID (CDSR [Nov 2013], CCTR [Nov 2013], DARE [4th Quarter 2013]).

Given the very large number of citations to screen and given the high priority that CCO attached to the update of this guideline, a decision was made to utilize additional staff resources in the title and abstract phase of the screening process. The objective of this process was to eliminate, as efficiently as possible, the obviously ineligible studies from further consideration and to keep any citations that either clearly met the eligibility criteria or for which it was not possible to determine eligibility simply from the title and abstract (i.e., full text review would be required).

Methods

Prior to screening, an orientation meeting was held with the five research coordinators (Adam Haynes, Judy Brown, Raymond Poon, Lisa Durocher, Sam Craigie) assigned to the project. Each research coordinator was provided with a document summarizing the original systematic review question and original study eligibility criteria (see *Eligibility Criteria* below). The eligibility criteria were presented at the meeting and expanded upon (but not altered from the original intent) based on discussion and agreement between the research coordinators.

A pseudo-random set of 500 citations was identified from the primary database of 19,764 citations. This set of 500 was screened in quintuplicate. The results of each research coordinator's review was entered into an Excel spreadsheet in order to calculate an agreement score using Fleiss' kappa using two categories: exclude vs. include/maybe. Records that had discrepant results (i.e., where one or more reviewers had a different screening result than other reviewers; e.g., four reviewers indicated a record should be excluded, but one reviewer indicated the same record was include or unsure) were identified. These records were discussed in a follow-up meeting where the research coordinators discussed the different results in order to come to agreement on the screening result (e.g., include, exclude, or maybe).

Results

When considering only two possible screening results (exclude or include/maybe), of the 500 random citations, 474 had concordant results between the research coordinators. Of note, three of those 474 records differed by assignment to include or maybe categories; however, for the purposes of this project, that was deemed an acceptable outcome as all records categorized to 'include' and 'maybe' were to be retrieved for further full text review. Twenty-six records had discordant results where one or more research coordinators assigned a category to a record that was different than the category assigned by the remaining research coordinators.

Eligibility Criteria

Original Study Eligibility Criteria

Inclusion Criteria

Reports were selected for inclusion in this systematic review of the evidence if they reported information on organizational resources relating to improved outcomes for patients undergoing cancer-related thoracic surgery. Patient-related outcomes of interest include: tumour response, local disease control, survival, adverse events, or quality of life.

Practice guidelines, meta-analyses, or systematic reviews related to the research question were also eligible for inclusion in the systematic review of the evidence.

Further information (not explicitly stated in original inclusion criteria):

- *Cancer-related thoracic surgery: surgery for lung or esophageal cancer. In theory this would also include thymomas.*
- *Organizational resources included the following factors: management of human, hospital and health care system resources.*
    - *The guideline addressed the following issues as they related to the outcomes of interest:*
        - *Surgeon criteria (education, training, expertise/specialty, experience)*
        - *Practice setting [e.g., hospital type, designated treatment centres (e.g., cancer centre, etc)), non-designated centres (e.g., general hospital)]*
        - *Volume of thoracic surgery* (from the aspect of treatment centre and surgeon)*
        - *Hospital criteria physical resources and collaborating services required to provide thoracic cancer surgery*
        - *Human resources (surgeons, anethesiologists, other medical specialists, allied health professionals (nurses, physiotherapists, respiratory therapists, dieticians/nutritionists, home care workers, social workers, pharmacy staff, palliative care professionals, etc)*
        - *Organizational criteria (e.g., how patients move through the system, how services are organized and offered to patients, organization of multidisciplinary teams, etc).*
- *Outcomes included in guideline but not stated in inclusion criteria:*
    - *Length of stay*
    - *Morbidity*
    - *30-day mortality*

*Note: *This seemed to be the focus of guideline and most of the included studies.*

Exclusion Criteria

Articles were excluded from the systematic review of the evidence if they reported information on thoracic surgeries for tumours in locations other than the lung or esophagus, if they were published or developed prior to 1990 and/or were in a language other than English.

Further information (not explicitly stated in the original exclusion criteria):

Exclude letters, editorials, comments, news articles, narrative reviews, non-*English papers.*

APPENDIX 2. List of Identified Studies Included in at Least One of the Systematic Reviews in Table 1.

Note: these studies were not included in Table 2.

Al-Sarira AA, David G, Willmott S, Slavin JP, Deakin M, Corless DJ. Oesophagectomy practice and outcomes in England. Br J Surg. 2007 May;94(5):585-91.

Allareddy V, Allareddy V, Konety BR. Specificity of procedure volume and in-hospital mortality association. Ann Surg. 2007 Jul;246(1):135-9.

Bilimoria KY, Bentrem DJ, Feinglass JM, Stewart AK, Winchester DP, Talamonti MS, et al. Directing surgical quality improvement initiatives: Comparison of perioperative mortality and long-term survival for cancer surgery. J Clin Oncol. 2008 01 Oct;26(28):4626-33.

Birkmeyer JD, Sun Y, Goldfaden A, Birkmeyer NJ, Stukel TA. Volume and process of care in high-risk cancer surgery. Cancer. 2006 Jun 1;106(11):2476-81.

Birkmeyer JD, Sun Y, Wong SL, Stukel TA. Hospital volume and late survival after cancer surgery. Ann Surg. 2007 May;245(5):777-83.

Cheung MC, Hamilton K, Sherman R, Byrne MM, Nguyen DM, Franceschi D, et al. Impact of teaching facility status and high-volume centers on outcomes for lung cancer resection: an examination of 13,469 surgical patients. Ann Surg Oncol. 2009 Jan;16(1):3-13.

Committee for Scientific Affairs, Kazui T, Osada H, Fujita H. An attempt to analyze the relation between hospital surgical volume and clinical outcome. Gen Thorac Cardiovasc Surg. 2007;55(12):483-92.

Dimick JB, Goodney PP, Orringer MB, Birkmeyer JD. Specialty training and mortality after esophageal cancer resection. Ann Thorac Surg. 2005 Jul;80(1):282-6.

Dimick JB, Wainess RM, Upchurch GR, Jr., Iannettoni MD, Orringer MB. National trends in outcomes for esophageal resection. Ann Thorac Surg. 2005 Jan;79(1):212-6; discussion 7-8.

Farjah F, Flum DR, Varghese TK, Jr., Symons RG, Wood DE. Surgeon specialty and long-term survival after pulmonary resection for lung cancer. Ann Thorac Surg. 2009 Apr;87(4):995-1004; discussion 5-6.

Forrest LM, McMillan DC, McArdle CS, Dunlop DJ. An evaluation of the impact of a multidisciplinary team, in a single centre, on treatment and survival in patients with inoperable non-small-cell lung cancer. Br J Cancer. 2005;93(9):977-8.

Freixinet JL, Julia-Serda G, Rodriguez PM, Santana NB, de Castro FR, Fiuza MD, et al. Hospital volume: operative morbidity, mortality and survival in thoracotomy for lung cancer. A Spanish multicenter study of 2994 cases. Eur J Cardiothorac Surg. 2006 Jan;29(1):20-5.

Fujita H, Ozawa S, Kuwano H, Ueda Y, Hattori S, Yanagawa T. Esophagectomy for cancer - Clinical concerns support centralizing operations to within the larger hospitals. Dis Esophagus. 2010 August;23:15A.

Fujita H, Ozawa S, Kuwano H, Ueda Y, Hattori S, Yanagawa T, et al. Esophagectomy for cancer: clinical concerns support centralizing operations within the larger hospitals. Dis Esophagus. 2010 Feb;23(2):145-52.

Funk LM, Gawande AA, Semel ME, Lipsitz SR, Berry WR, Zinner MJ, et al. Esophagectomy outcomes at low-volume hospitals: the association between systems characteristics and mortality. Ann Surg. 2011 May;253(5):912-7.

Gasper WJ, Glidden DV, Jin C, Way LW, Patti MG. Has recognition of the relationship between mortality rates and hospital volume for major cancer surgery in California made a difference?: A follow-up analysis of another decade. Ann Surg. 2009 Sep;250(3):472-83.

Goodney PP, Stukel TA, Lucas FL, Finlayson EVA, Birkmeyer JD. Hospital Volume, Length of Stay, and Readmission Rates in High-Risk Surgery. Ann Surg. 2003 August;238(2):161-7.

Gordon TA, Bowman HM, Bass EB, Lillemoe KD, Yeo CJ, Heitmiller RF, et al. Complex gastrointestinal surgery: impact of provider experience on clinical and economic outcomes. J Am Coll Surg. 1999;189(1):46-56.

Ho V, Heslin MJ, Yun H, Howard L. Trends in hospital and surgeon volume and operative mortality for cancer surgery. Ann Surg Oncol. 2006 Jun;13(6):851-8.

Hollenbeck BK, Dunn RL, Miller DC, Daignault S, Taub DA, Wei JT. Volume-based referral for cancer surgery: informing the debate. J Clin Oncol. 2007;25(1):91-6.

Hollenbeck BK, Hong J, Zaojun Y, Birkmeyer JD. Misclassification of hospital volume with Surveillance, Epidemiology, and End Results Medicare data. Surg Innov. 2007 Sep;14(3):192-8.

Kee F, Owen T, Leathem R. Decision making in a multidisciplinary cancer team: does team discussion result in better quality decisions? Med Decis Making. 2004;24(6):602-13.

Kim SY, Park JH, Kim SG, Woo HK, Park JH, Kim Y, et al. Disparities in utilization of high-volume hospitals for cancer surgery: results of a Korean population-based study. Ann Surg Oncol. 2010 Nov;17(11):2806-15.

Leo F, Venissac N, Poudenx M, Otto J, Mouroux J, Groupe d'Oncologie Thoracique A. Multidisciplinary management of lung cancer: how to test its efficacy? Journal of Thoracic Oncology: Official Publication of the International Association for the Study of Lung Cancer. 2007 Jan;2(1):69-72.

Li WW, Visser O, Ubbink DT, Klomp HM, Kloek JJ, de Mol BA. The influence of provider characteristics on resection rates and survival in patients with localized non-small cell lung cancer. Lung Cancer. 2008 Jun;60(3):441-51.

Lien YC, Huang MT, Lin HC. Association between surgeon and hospital volume and in-hospital fatalities after lung cancer resections: the experience of an Asian country. Ann Thorac Surg. 2007 May;83(5):1837-43.

Lin HC, Xirasagar S, Lee HC, Chai CY. Hospital volume and inpatient mortality after cancer-related gastrointestinal resections: the experience of an Asian country. Ann Surg Oncol.

2006 Sep;13(9):1182-8.

Meguid RA, Weiss ES, Chang DC, Brock MV, Yang SC. The effect of volume on esophageal cancer resections: what constitutes acceptable resection volumes for centers of excellence? J Thorac Cardiovasc Surg. 2009 Jan;137(1):23-9.

Migliore M, Choong CK, Lim E, Goldsmith KA, Ritchie A, Wells FC. A surgeon's case volume of oesophagectomy for cancer strongly influences the operative mortality rate. Eur J Cardiothorac Surg. 2007 Aug;32(2):375-80.

Murray PV, O'Brien MER, Sayer R, Cooke N, Knowles G, Miller AC, et al. The pathway study: results of a pilot feasibility study in patients suspected of having lung carcinoma investigated in a conventional chest clinic setting compared to a centralised two-stop pathway. Lung Cancer. 2003;24(3):283-90.

Osada H, Yamakoshi E. Hospital volume and surgical outcomes of lung cancer in Japan. Gen Thorac Cardiovasc Surg. 2007 Sep;55(9):360-5.

Pal N, Axisa B, Yusof S, Newcombe RG, Wemyss-Holden S, Rhodes M, et al. Volume and outcome for major upper GI surgery in England. J Gastrointest Surg. 2008 Feb;12(2):353-7.

Ra J, Paulson EC, Kucharczuk J, Armstrong K, Wirtalla C, Rapaport-Kelz R, et al. Postoperative mortality after esophagectomy for cancer: development of a preoperative risk prediction model.[Erratum appears in Ann Surg Oncol. 2009 Jan;16(1):228]. Ann Surg Oncol. 2008 Jun;15(6):1577-84.

Reavis KM, Smith BR, Hinojosa MW, Nguyen NT. Outcomes of esophagectomy at academic centers: an association between volume and outcome. Am Surg. 2008 Oct;74(10):939-43.

Rodgers M, Jobe BA, O'Rourke RW, Sheppard B, Diggs B, Hunter JG. Case volume as a predictor of inpatient mortality after esophagectomy. Arch Surg. 2007 Sep;142(9):829-39.

Rouvelas I, Jia C, Viklund P, Lindblad M, Lagergren J. Surgeon volume and postoperative mortality after oesophagectomy for cancer. Eur J Surg Oncol. 2007 Mar;33(2):162-8.

Rouvelas I, Lindblad M, Zeng W, Viklund P, Ye W, Lagergren J. Impact of hospital volume on long-term survival after esophageal cancer surgery. Arch Surg. 2007 Feb;142(2):113-7.

Rutegard M, Lagergren J, Rouvelas I, Lagergren P. Surgeon volume is a poor proxy for skill in esophageal cancer surgery. Ann Surg. 2009 Feb;249(2):256-61.

Rutegard M, Lagergren P. No influence of surgical volume on patients' health-related quality of life after esophageal cancer resection. Ann Surg Oncol. 2008 Sep;15(9):2380-7.

Schipper PH, Diggs BS, Ungerleider RM, Welke KF. The influence of surgeon specialty on outcomes in general thoracic surgery: a national sample 1996 to 2005. Ann Thorac Surg. 2009 Nov;88(5):1566-72; discussion 72-3.

Simunovic M, Rempel E, Theriault ME, Coates A, Whelan T, Holowaty E, et al. Influence of hospital characteristics on operative death and survival of patients after major cancer

surgery in Ontario. Can J Surg. 2006 Aug;49(4):251-8.

Sioris T, Sihvo E, Sankila R, Salo J. Effect of surgical volume and hospital type on outcome in non-small cell lung cancer surgery: a Finnish population-based study. Lung Cancer. 2008 Jan;59(1):119-25.

Stavrou EP, Smith GS, Baker DF. Surgical outcomes associated with oesophagectomy in New South Wales: an investigation of hospital volume. J Gastrointest Surg. 2010 Jun;14(6):951-7.

Stephens MR, Lewis WG, Brewster AE, Lord I, Blackshaw GR, Hodzovic I, et al. Multidisciplinary team management is associated with improved outcomes after surgery for esophageal cancer. Dis Esophagus. 2006;19(3):164-71.

Sundelof M, Lagergren J, Ye W. Surgical factors influencing outcomes in patients resected for cancer of the esophagus or gastric cardia. World J Surg. 2008 Nov;32(11):2357-65.

Suzuki H, Gotoh M, Sugihara K, Kitagawa Y, Kimura W, Kondo S, et al. Nationwide survey and establishment of a clinical database for gastrointestinal surgery in Japan: Targeting integration of a cancer registration system and improving the outcome of cancer treatment. Cancer Sci. 2011 Jan;102(1):226-30.

Thompson AM, Rapson T, Gilbert FJ, Park KG, Scottish Audit of G, Oesophageal C. Hospital volume does not influence long-term survival of patients undergoing surgery for oesophageal or gastric cancer. Br J Surg. 2007 May;94(5):578-84.

Urbach DR, Austin PC. Conventional models overestimate the statistical significance of volume-outcome associations, compared with multilevel models. J Clin Epidemiol. 2005 Apr;58(4):391-400.

Urbach DR, Baxter NN. Does it matter what a hospital is "high volume" for? Specificity of hospital volume-outcome associations for surgical procedures: analysis of administrative data. Quality & Safety in Health Care. 2004 Oct;13(5):379-83.

Urbach DR, Bell CM, Austin PC. Differences in operative mortality between high- and low-volume hospitals in Ontario for 5 major surgical procedures: Estimating the number of lives potentially saved through regionalization. CMAJ. 2003 27 May;168(11):1409-14.

Viklund P, Lindblad M, Lu M, Ye W, Johansson J, Lagergren J. Risk factors for complications after esophageal cancer resection: a prospective population-based study in Sweden. Ann Surg. 2006 Feb;243(2):204-11.

Ward MM, Jaana M, Wakefield DS, Ohsfeldt RL, Schneider JE, Miller T, et al. What would be the effect of referral to high-volume hospitals in a largely rural state? J Rural Health. 2004;20(4):344-54.

Wenner J, Zilling T, Bladstrom A, Alvegard TA. The influence of surgical volume on hospital mortality and 5-year survival for carcinoma of the oesophagus and gastric cardia. Anticancer Res. 2005 Jan-Feb;25(1B):419-24.

Wouters MW, Karim-Kos HE, le Cessie S, Wijnhoven BP, Stassen LP, Steup WH, et al.

Centralization of esophageal cancer surgery: does it improve clinical outcome? Ann Surg Oncol. 2009 Jul;16(7):1789-98.

Wright CD, Kucharczuk JC, O'Brien SM, Grab JD, Allen MS, Society of Thoracic Surgeons General Thoracic Surgery D. Predictors of major morbidity and mortality after esophagectomy for esophageal cancer: a Society of Thoracic Surgeons General Thoracic Surgery Database risk adjustment model.[Erratum appears in J Thorac Cardiovasc Surg. 2009 Jun;137(6):1581]. J Thorac Cardiovasc Surg. 2009 Mar;137(3):587-95; discussion 96.

Appendix 3: Members of the Expert Panel in March 2015

The 2015 Expert Panel was convened to include representation from across Ontario and across professional disciplines (surgery, pathology, radiology, medical oncology and radiation oncology).

Dr. Gail Darling (Co-Chair), Surgeon Toronto General Hospital Ontario Thoracic Cancers Lead	Dr. Alice Wei (Co-Chair), Surgeon Quality Lead, Cancer Care Ontario Surgical Oncology Program
Dr. Claudia Den Boer Grima Regional Vice-President Windsor Regional Cancer Program	Dr. John Dickie, Surgeon Lakeridge Health Corporation Oshawa
Dr. Peter Ellis, Medical Oncologist Juravinski Cancer Centre, Hamilton	Dr. David Ewing-Bui, Surgeon Sudbury Regional Hospital
Dr. Kenneth Gehman, Surgeon Thunder Bay	Dr. Marcio Gomes, Pathologist The Ottawa Hospital
Dr. David Hwang, Pathologist Toronto General Hospital	Dr. Jonathan Irish Clinical Lead – Cancer Care Ontario Surgical Oncology Program
Dr. Neil Johnson Regional Vice-President London Regional Cancer Program	Dr. Richard Malthaner, Surgeon London Health Sciences Centre
Dr. Craig McFadyen Regional Vice-President Carlo Fidani Peel Regional Cancer Program	Dr. Yaron Shargall, Surgeon St. Joseph's Healthcare Hamilton
Dr. Amit Singnurkar, Nuclear Medicine Hamilton Health Sciences	Dr. Julius Toth, Surgeon Newmarket
Dr. Yee Ung, Radiation Oncologist Odette Cancer Centre Toronto	

Appendix 4- Document Assessment and Review Outcome Definitions

1. **EDUCATION AND INFORMATION** – An education and information document is a document that will no longer be tracked or updated but may still be useful for academic or other informational purposes. The document is moved to a separate section of our website, each page is watermarked with the word "EDUCATION AND INFORMATION".

2. **ENDORSED** – An endorsed document is a document that the DSG/GDG has reviewed for currency and relevance and determined to be still useful as guidance for clinical decision making. A document may be endorsed because the DSG/GDG feels the current recommendations and evidence are sufficient, or it may be endorsed after a literature search uncovers no evidence that would alter the recommendations in any important way.

3. **DELAY –** A delay means that there is reason to believe new, important evidence will be released within the next year that should be considered before taking further action.

4. **UPDATE** – An Update means that the DSG/GDG recognizes that there is new evidence that makes changes to the existing recommendations in the guideline necessary but these changes are more involved and significant than can be accomplished through the Document Assessment and Review process. The DSG/GDG will rewrite the guideline at the earliest opportunity to reflect this new evidence. Until that time, the document will still be available as its existing recommendations are still of some use in clinical decision making.

Evidence-Based Series #17-1 Version 2: Section 5

Thoracic Surgical Oncology Standards: Review of Esophageal Cancer Surgery Recommendations

F.C. Wright, G. Darling, J. Irish, and the Thoracic Standards Esophageal Expert Panel

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OVERVIEW

The original version of the Thoracic Surgical Oncology Standards was released by Ontario Health (Cancer Care Ontario)'s Program in Evidence-Based Care, in collaboration with the Surgical Oncology Program (SOP), in 2005. In February 2020 the SOP elected to review the standards recommendations related to the treatment of cancer-related esophagectomies at designated centres in Ontario, particularly the recommendations related to the minimum surgical volume and supporting resource requirements. As part of this review, an updated literature search was performed and Ontario data on surgical outcomes was analyzed. A multidisciplinary province-wide Thoracic Standards Esophageal Expert Panel (see Appendix A) was established to review the updated literature and outcome data and determine if any modifications to the recommendations would be appropriate. The Thoracic Standards Esophageal Expert Panel met twice in the spring of 2021 and determined that the literature and data supported a change to both the minimum surgical volume and resource requirement recommendations.

REVIEW RESULTS

Literature Search and New Evidence

An updated literature search (Dec 2013 – Feb 2020) was performed to assess if there was newly available evidence supporting the volume-outcome relationship for esophageal cancer surgery. The target population was adult patients (> 18 years old) who underwent cancer-related esophagectomy. Using a comprehensive search strategy, the Ovid Medline, Ovid EMBASE and Cochrane Database of Systematic Reviews was searched, as well as the grey literature, for English-language primary evidence (primary articles, systematic reviews and/or meta-analysis, guidelines). The search yielded a total of 48 articles meeting the eligibility criteria (46 observational studies and 2 systematic reviews/meta-analyses). The content of this literature review is available on request from the OH (CCO) Surgical Oncology Program (SOPInfo@ontariohealth.ca).

Ontario Data

Ontario data on surgical outcome quality indicators (30-day and 90-day mortality, re-operation 30-days after surgery, and re-admission/unplanned hospital visit 30 days after surgery) for cancer-related esophagectomies was analyzed and reviewed by the Thoracic Standards Esophageal Expert Panel. The data for these indicators was sourced from the Canadian Institute for Health Information, the Discharge Abstracts Database, the National Ambulatory Care Reporting System, and the Registered Persons Database.

Impact on the Guideline and Recommendations

After reviewing the literature and the Ontario data the Thoracic Standards Esophageal Expert Panel supported an update to the cancer-related esophagectomy recommendations.

Despite heterogeneity in the included studies of the literature review, the majority of the studies pointed towards a relationship between higher volume hospitals and surgeons having

better outcomes. Several studies noted that 15 esophageal resections per year at an institution was the significant cut-off point that distinguished low-volume and high-volume centres with regards to mortality. Importantly in a number of studies that reported improved outcomes after regionalization/ centralization (and higher volumes), the authors all cautioned improved outcomes could not be attributed to higher volume alone suggesting that there are other factors at play, such as the expertise of the multidisciplinary surgical team, care pathways, and post-operative care that contribute to improved patient outcomes.

Ontario surgical outcome data showed variation across the province for 30-day post-operative reoperation rates and 30-day post-operative unplanned hospital visit rates, with Level 1 Designated Centres performing better than Level 2 Designated Centres in some years and vice versa in other years. However, data for 30-day and 90-day post-operative mortality demonstrated a clear difference in outcomes between Level 1 and Level 2 centres, with Level 1 Designated Centres consistently having lower mortality rates. To identify the ideal minimum esophageal surgical volume threshold, the 30- and 90-day mortality rates data was further analyzed and stratified by the following annual average hospital volume categories: <=7 cases/year, 8-12 cases/year, 12-15 cases/year, and 16-19 cases/year. It was found that in the context of Ontario hospital data, both 30-day and 90-day mortality rates improved when a minimum of 12-15 esophagectomies were performed at a centre each year.

After review of the literature and the Ontario data, the Expert Panel agreed that it would be appropriate to update the recommendations related to the minimum surgical volume and resource requirements for centres performing cancer-related esophagectomies. Specifically:

1. Based on the finding that the significant decrease in mortality occurred at the cut-off range of 12-15 esophagectomies per year, the Expert Panel agreed that 15 esophagectomies should be completed per year at any centre performing esophageal cancer surgery. This would decrease the minimum surgical volume requirement at Level 1 Designated Centres from 20 cases/year to 15 cases/year, and would increase the minimum surgical volume requirement at Level 2 Designated Centres from 7 cases/year to 15 cases/year.
2. The Expert Panel agreed that any centre offering cancer-related esophagectomy should meet the institutional requirements of a Level 1 centre, including three thoracic surgeons.

These recommendation changes reflect the importance of ensuring access to the full spectrum of human and physical resources required to treat these complex cases. There are no changes to any of the recommendations pertaining to cancer-related lung surgery.

Appendix A. Thoracic Standards Esophageal Expert Panel Members

Name	Hospital/Region	Discipline or Role
Dr. Abdusalam Elalem	Windsor Regional Hospital	Thoracic Surgery
Nicole Sbrocca	Erie St. Clair	Regional Director
Dr. Rick Malthaner	London Health Sciences Centre	Thoracic Surgery
Dr. Matt Kilmurry	St. Mary's General Hospital	Thoracic Surgery
Dr. Yaron Shargall	St. Joseph's Healthcare, Hamilton	Thoracic Surgery
Dr. Anna Bendzsak	William Osler	Thoracic Surgery
Dr. Sameena Uddin	Trillium Health Partners	Thoracic Surgery
Dr. Yee Ung	Sunnybrook Health Sciences Centre	Radiation Oncology
Dr. Calvin Law	Toronto Central North	Regional Vice President
Dr. Najib Safieddine	Michael Garron Hospital	Thoracic Surgery
Dr. Pauline Henry	Michael Garron Hospital	Pathology
Dr. Gail Darling	UHN	Thoracic Surgery
Dr. Elena Elimova	UHN/PMH	Medical Oncology
Dr. Julius Toth	Southlake Regional Health Centre	Thoracic Surgery
Dr. John Dickie	Lakeridge Health	Thoracic Surgery
Dr. Wiley Chung	Kingston General Hospital	Thoracic Surgery
Dr. Jordan Sim	The Ottawa Hospital	Pathology
Dr. Donna Maziak	The Ottawa Hospital	Thoracic Surgery
Dr. Sudhir Sundaresan	The Ottawa Hospital	Thoracic Surgery
Dr. Shona Smith	Health Sciences North	Thoracic Surgery
Dr. James Masters	Health Sciences North	Regional Surgical Oncology Lead
Dr. Ken Gehman	Thunder Bay Health Sciences Centre	Thoracic Surgery
Dr. Joseph Del Paggio	Thunder Bay Health Sciences Centre	Medical Oncology
Dr. Jonathan Irish	Surgical Oncology Program, Ontario Health (Cancer Care Ontario)	Provincial Head
Dr. Frances Wright	Surgical Oncology Program, Ontario Health (Cancer Care Ontario)	Clinical Lead, Quality & Knowledge Transfer
Amber Hunter	Surgical Oncology Program, Ontario Health (Cancer Care Ontario)	Program Manager
Leigh McKnight	Surgical Oncology Program, Ontario Health (Cancer Care Ontario)	Program Lead