Improvement of the multimodality treatment of oesophageal cancer
Courrech Staal, E.F.W.

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Citation for published version (APA):

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Quality-of-care indicators for oesophageal cancer surgery: a review


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Michel WJM Wouters
Henk Boot
Rob AEM Tollenaar
Johanna W van Sandick
Abstract

Background
Quality-of-care indicators are measurable elements of practice performance that can assess the (change in) quality of the care provided. To date, the literature on quality-of-care indicators for oesophageal cancer surgery has not been reviewed.

Methods
We performed a review of the literature on quality-of-care indicators for oesophageal cancer surgery. The indicators were classified by their nature of care provision (structural, process, or outcome).

Results
One hundred thirty articles were included. For structural measures, most evidence was found for the inverse relationship between hospital or surgeon volume and postoperative mortality. Few articles described the required infrastructural and organisational elements for oesophageal cancer surgery. Regarding process measures, the most common indicators were determinants of patient selection for surgery. Other process indicators with considerable evidence were found (e.g., multidisciplinary team management), though the number of studies was small. For outcome indicators, the level of evidence for pathological outcome measures was strong. Data on postoperative complications as outcome indicators varied widely.

Conclusion
Since there is considerable variation in the evaluation of quality of care, the uniform use of well-defined quality-of-care indicators to measure and document practice performance holds the promise of improving outcome in patients who undergo oesophageal cancer surgery.
Introduction

Quality assurance in the treatment of cancer is gaining importance since many studies have shown variation in outcome between different providers. In Europe, quality assurance programmes have been introduced in the field of radiotherapy as well as for medical oncology, however, surgical quality control has received less attention.\(^1\) Only recently, the European Society for Surgical Oncology (ESSO) has started an international audit program for rectal cancer treatment.\(^3\) Few attempts have been made to spread the merits of quality assurance programmes to other tumour types.

Evidence-based guidelines that have been developed for a large variety of cancer treatments worldwide are seldom accompanied by well-defined standards for the evaluation of the quality of surgical care. Donabedian has conceptualized the evaluation of patient care in terms of structure, process, and outcome measures.\(^5\)

Oesophageal cancer ranks sixth on the list of cancer mortality worldwide.\(^6\) In 2008, the incidence in the Netherlands was around 1850 patients per year.\(^7\) It has been recommended to concentrate the surgical treatment of oesophageal cancer in high-volume. The effectiveness of such measures in raising the whole level of care has been questioned.\(^8\) Preferably, the concentration of oesophageal cancer treatment is accompanied by a national quality assurance program, evaluating the different dimensions of quality of care in all hospitals taking care of these patients.\(^9\) A practical definition of quality of care would be the degree to which health services achieve a level of care deemed adequate by evidence-based quality measures.\(^10\)

We have performed a review of the literature to identify evidence-based standards for high-level quality of care for oesophageal cancer patients who are candidates for surgical therapy. We used the Donabedian quality-of-care model to categorize the identified standards. Furthermore, we aimed to construct a minimum dataset of evidence-based quality-of-care indicators for future registration and benchmarking.

Materials and Methods

Search strategy

A search of the literature on PubMed was performed to find articles published between January 1990 and October 2009 on quality of care in the surgical treatment of oesophageal cancer. Three Medical Subject Heading (MeSH) terms were used: ‘oesophageal neoplasms’, ‘surgery’ and ‘oesophagectomy’. Studies describing aspects of quality of care were searched by combining these three MeSH terms with the following keywords: ‘benchmarking’, ‘health
Articles were selected on the basis of their relevance using pre-defined in- and exclusion criteria (Figure 1). Many studies were excluded because they were non-comparative studies. Only original articles were considered for inclusion. Selection was performed independently by two investigators (ECS and MW). A third reviewer (JvS) was consulted in case of disagreement. One hundred thirty articles were included.
Classification of studies
Articles were categorized according to the primary subject of the study: structural, process or outcome measures. Structural components of care are characteristics of the provider, reflecting the setting in which care is delivered (e.g. staff expertise). Process components of care refer to the interactions between the provider (i.e., physician) and the patient (e.g., staging process). Outcome characteristics are measurable short-term outcomes affecting the final outcome of patients (e.g., radicality of resection).

Level of evidence
Of 130 included articles, 13 were randomised controlled trials, 26 were prospective (cohort) studies and 91 were retrospective studies. Because of the comparable level of evidence for most of these included studies, we classified results of evidence according to a scoring system used in a previous article by Lagarde et al: none (no evidence), minor (only evidence from univariate analysis), considerable (evidence from uni- and multivariate analysis), strong (evidence from several multivariate analyses or evidence from univariate analysis in at least ten articles).11

Only characteristics with strong evidence or those with considerable evidence based on at least three articles were entered into a minimum dataset of 'evidence-based' quality-of-care indicators for oesophageal cancer surgery.

Structural measures

Structural variables with corresponding articles are listed in Table 1.

Volume
A wide variation in definitions of hospital volume was found in the various studies on hospital volume and mortality rates (e.g., the definition of high-volume ranged from 6 to 40 resections per year).12-36 Besides the clear association between high volume and low mortality rates, also lower complication rates and shorter admission times have been found in high-volume hospitals as compared to low-volume hospitals.12;15;23;24;34;35;37;38 Consequently, treatment in high-volume hospitals has been associated with a decrease in hospital charges.12;14-16;18 Other clinical endpoints, such as long-term survival and quality of life, have been studied less often. Two out of three studies20;39;40 could not demonstrate a survival benefit in high-volume hospitals20;39 and one other study did not find an improved quality of life.41

As in studies on the influence of hospital volume, higher annual case volume per surgeon has been associated with lower postoperative mortality rates.19;20;31;42-48
Table 1: Structural measures for quality of care in oesophageal cancer surgery

<table>
<thead>
<tr>
<th>Structural measure</th>
<th>End point</th>
<th>Favouring</th>
<th>Nr of articles favouring</th>
<th>Level of evidence</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hospital volume</strong></td>
<td>Postoperative mortality</td>
<td>High-volume hospital</td>
<td>22 out of 25</td>
<td>strong</td>
<td>12-36</td>
</tr>
<tr>
<td>(high versus low)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Postoperative morbidity</td>
<td>High-volume hospital</td>
<td>5 out of 8</td>
<td>considerable</td>
<td>12;15;24;34;35;37;38</td>
</tr>
<tr>
<td></td>
<td>Postoperative ICU-stay</td>
<td>High-volume hospital</td>
<td>1 out of 1</td>
<td>minor</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Postoperative hospital stay</td>
<td>High-volume hospital</td>
<td>6 out of 8</td>
<td>considerable</td>
<td>12;14;16;18;34;35;37</td>
</tr>
<tr>
<td></td>
<td>Survival</td>
<td>High-volume hospital</td>
<td>1 out of 3</td>
<td>minor</td>
<td>20;39;40</td>
</tr>
<tr>
<td></td>
<td>Quality of life</td>
<td>--</td>
<td>0 out of 1</td>
<td>none</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Costs</td>
<td>High-volume hospital</td>
<td>5 out of 5</td>
<td>considerable</td>
<td>12;14-16;18</td>
</tr>
</tbody>
</table>

| **Surgeon volume**       | Postoperative mortality         | High-volume surgeon | 9 out of 10            | strong            | 19;20;31;42-48 |
| (high versus low)        |                                |                 |                          |                   |            |
|                          | Postoperative morbidity         | High-volume surgeon | 1 out of 1              | considerable      | 37         |
|                          | Postoperative hospital stay     | High-volume surgeon | 1 out of 1              | considerable      | 37         |
|                          | Anastomotic leakage            | High-volume surgeon | 1 out of 2              | considerable      | 49;45      |
|                          | Survival                        | High-volume surgeon | 2 out of 4              | considerable      | 19;20;44;46 |
|                          | Quality of life                 | --              | 0 out of 1              | none              | 41         |

| **Specialty training**   | Postoperative mortality         | Thoracic surgeon | 2 out of 3              | considerable      | 36;40;50   |
| (general versus thora-   |                                |                 |                          |                   |            |
| cic surgeon)             | Postoperative morbidity         | --              | 0 out of 1              | none              | 50         |
|                          | Postoperative ICU-stay          | --              | 0 out of 1              | none              | 50         |
|                          | Postoperative hospital stay     | --              | 0 out of 1              | none              | 50         |

| **ICU physician staffing** | Postoperative mortality       | --              | 0 out of 1              | none              | 51         |
| (daily rounds versus no daily rounds) | | | | |
| Postoperative morbidity  | Daily ICU rounds               | 1 out of 1      | considerable            | 51               |
| Postoperative hospital stay | Daily ICU rounds               | 1 out of 1      | considerable            | 51               |
|                          | Costs                          | Daily ICU rounds | 1 out of 1              | considerable      | 51         |

| **ICU nurse-to-patient ratio** | Postoperative mortality | --              | 0 out of 1              | none              | 52         |
| (1 or 2 versus ≥3 patients per nurse) | Postoperative morbidity  | 1 or 2 patients /nurse | 1 out of 1 | minor | 52 |
| Postoperative hospital stay | 1 or 2 patients /nurse     | 1 out of 1      | minor                  | 52               |
| Costs                       | 1 or 2 patients /nurse       | 1 out of 1      | minor                  | 52               |
Quality-of-care indicators for oesophageal cancer surgery

Specialization
Volume is related to, but does not equal specialization. Three studies have reported on the influence of subspecialty training of the surgeon on outcome (Table 1).\textsuperscript{36,49,50} In two studies, a lower postoperative mortality rate has been found in patients operated on by cardiothoracic surgeons as compared to that in patients operated on by a general surgeon.\textsuperscript{36,49} The third study reported no significant differences in outcome between general and thoracic surgeons.\textsuperscript{50} To date, no comparisons between dedicated upper gastrointestinal and general surgical oncologists have been made.

Organization
Few studies specifically addressed the impact of organization of care on the outcome of surgically treated oesophageal cancer patients. In one study, daily rounds by an ICU physician were associated with shorter lengths of stay, lower hospital cost, and less postoperative complications after oesophageal resection, but not with a lower in-hospital mortality rate.\textsuperscript{51} In an other large study, a comparison between 225 patients with a night-time nurse-to-patient ratio of 1:1 or 1:2 and 128 patients with a night-time nurse-to-patient ratio of 1:3 or more was made.\textsuperscript{52} Patients in the second group had an increased risk of postoperative complications after oesophageal resection which was associated with an increased use of resources.

Centralization
Following the relationship between volume/specialization and outcome, one may expect that centralization of oesophagectomies at high-volume providers improves outcome. Few studies have actually demonstrated this.\textsuperscript{9,15,53} Recently, we have shown a dramatic improvement in mortality and survival after centralization of oesophageal cancer surgery

<table>
<thead>
<tr>
<th>Structural measure</th>
<th>End point</th>
<th>Favouring</th>
<th>Nr of articles favouring</th>
<th>Level of evidence</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centralization</td>
<td>Postoperative mortality</td>
<td>Referral centre</td>
<td>3 out of 3</td>
<td>considerable</td>
<td>\textsuperscript{9,15,53}</td>
</tr>
<tr>
<td>(referral versus regional centre)</td>
<td>Postoperative morbidity</td>
<td>Referral centre</td>
<td>1 out of 2</td>
<td>minor</td>
<td>\textsuperscript{9,53}</td>
</tr>
<tr>
<td></td>
<td>Survival</td>
<td>--</td>
<td>0 out of 1</td>
<td>none</td>
<td>\textsuperscript{9}</td>
</tr>
</tbody>
</table>

Abbreviations: ICU: Intensive Care Unit
None: no evidence; minor: only evidence from univariate analysis; considerable: evidence from uni- and multivariate analysis; strong: evidence from several multivariate analyses or evidence from univariate analysis in 10 or more articles.
in a region of the Netherlands. This centralization process was accompanied by feedback of detailed clinical data to individual hospitals and surgeons (surgical audit).

**Process measures**

Process variables with corresponding articles are listed in Table 2.

**Patient selection**

In several studies, the influence of old age was investigated. In a minority of studies, older age was associated with an unfavourable postoperative outcome.

The use of a risk score may be a quality indicator. Bartels et al evaluated a risk scoring model in a prospective setting and found a marked reduction in post-operative deaths due to better patient selection.

The relationship between the preoperative nutritional status and the outcome of surgery in patients with oesophageal carcinoma has shown conflicting results. In one study, underweight patients who underwent major intra-abdominal surgery, e.g., oesophagectomy, had a five-fold increased risk of postoperative mortality. Though, other studies including exclusively oesophageal cancer patients have not confirmed this. In four studies, complication rates for obese patients equalled those for non-obese patients.

The role of race and socio-economic status on patient selection has received some attention. In the United States, African-American patients with oesophageal cancer were less likely to undergo surgical resection compared to Caucasian patients. In the Netherlands, low socio-economic status proved to be associated with a lower chance of resection. These disparities are not fully explained by differences in medical factors.

It has been suggested that patients’ but possibly also physicians’ preferences might differ among different socio-economic groups of patients.

In one study, there was a relationship between better pretreatment quality of life and lower postoperative mortality. Especially reduced physical function as an aspect of pretreatment quality of life was predictive of lower survival in several studies.

**Staging**

For high-risk surgical procedures, it is important to select only those patients who can be cured. For computed tomography (CT) examination, the level of experience of the radiologist appeared to influence the detection of metastases in patients with oesophageal cancer. Fluorodeoxyglucose positron emission tomography (FDG-PET) has shown its incremental value with the identification of 5 to 17% additional patients with metastases. Van Vliet
et al studied the results of endoscopic ultrasonography (EUS) performed in low-volume EUS-centres and found unfavourable results in comparison with those in high-volume EUS-centres\textsuperscript{90}

**Treatment choices**

*Multimodality treatment*

Several studies have compared the use of neoadjuvant chemoradiation with surgery alone for patients with oesophageal cancer.\textsuperscript{91-107} Although a negative effect of neoadjuvant treatment on postoperative morbidity\textsuperscript{106} and mortality\textsuperscript{95} was found in two separate studies, most studies could not demonstrate these differences.\textsuperscript{91-93;97;98;101;103-105;107} Regarding overall survival, there was a benefit of neoadjuvant chemoradiation in two out of 11 studies.\textsuperscript{94;105}

*Multidisciplinary team*

It is generally believed that a multidisciplinary approach in cancer treatment results in the best achievable outcomes. The added value is hardly measurable. Nevertheless, in a study by Stephens et al, the selection, staging and treatment of patients eligible for oesophagectomy by a multidisciplinary team resulted in a better survival as compared to the survival of patients treated by surgeons alone.\textsuperscript{108}

*Surgical approach*

Four randomized trials have compared the outcome of a limited transhiatal approach versus an extended transthoracic approach.\textsuperscript{109-112} Differences in postoperative morbidity were in favour of a limited transhiatal approach, and one trial showed a trend towards better survival in patients operated via an extended transthoracic approach.\textsuperscript{112} Complete 5-year survival data suggested that patients with a tumour in the distal oesophagus had benefitted from an extended transthoracic resection.\textsuperscript{113}

*Peri-operative care*

Watson *et al* showed that respiratory complications decreased from 30 to 13% and death due to these complications from 5 to 0%, after introducing the routine use of thoracic epidural analgesia (TEA).\textsuperscript{114} In an other series, TEA lowered the anastomotic leakage rate.\textsuperscript{115} The authors suggested a causal relationship between hypoxemia and hypotension due to respiratory hypofunction in patients undergoing oesophagectomy without the use of TEA. It has also been shown that the use of TEA enables early discharge of patients after oesophagectomy.\textsuperscript{116}
Table 2: Process measures: patient selection, staging and treatment choices for quality of care in oesophageal cancer surgery

<table>
<thead>
<tr>
<th>Process measure</th>
<th>End point</th>
<th>Favouring</th>
<th>Nr of articles favouring</th>
<th>Level of evidence</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(&lt; 70 years versus &gt; 70 years)</td>
<td>Postoperative mortality</td>
<td>No age limit</td>
<td>11 out of 11</td>
<td>strong</td>
<td>54-64</td>
</tr>
<tr>
<td></td>
<td>Postoperative morbidity</td>
<td>&lt; 70 years</td>
<td>4 out of 11</td>
<td>minor</td>
<td>54-64</td>
</tr>
<tr>
<td></td>
<td>Survival</td>
<td>No age limit</td>
<td>11 out of 11</td>
<td>strong</td>
<td>54-64</td>
</tr>
<tr>
<td>(&lt; 80 years versus &gt; 80 years)</td>
<td>Postoperative mortality</td>
<td>&lt; 80 years</td>
<td>1 out of 4</td>
<td>minor</td>
<td>54;63;65;66</td>
</tr>
<tr>
<td></td>
<td>Postoperative morbidity</td>
<td>&lt; 80 years</td>
<td>2 out of 4</td>
<td>considerable</td>
<td>54;63;65;66</td>
</tr>
<tr>
<td></td>
<td>Survival</td>
<td>&lt; 80 years</td>
<td>1 out of 4</td>
<td>minor</td>
<td>54;63;65;66</td>
</tr>
<tr>
<td>Use of risk score</td>
<td>Postoperative mortality</td>
<td>Use of risk score</td>
<td>1 out of 1</td>
<td>minor</td>
<td>67</td>
</tr>
<tr>
<td>(yes versus no)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nutritional status</td>
<td>Postoperative mortality</td>
<td>Normal weight</td>
<td>1 out of 2</td>
<td>minor</td>
<td>68;69</td>
</tr>
<tr>
<td>(normal weight versus cachexia)</td>
<td>Postoperative morbidity</td>
<td>Normal weight</td>
<td>1 out of 3</td>
<td>minor</td>
<td>68;70</td>
</tr>
<tr>
<td>(normal weight versus obesity)</td>
<td>Postoperative mortality</td>
<td>--</td>
<td>0 out of 2</td>
<td>none</td>
<td>68;69</td>
</tr>
<tr>
<td></td>
<td>Postoperative morbidity</td>
<td>--</td>
<td>0 out of 4</td>
<td>none</td>
<td>68;71</td>
</tr>
<tr>
<td>Socio-economic status</td>
<td>Surgical resection</td>
<td>White race</td>
<td>3 out of 3</td>
<td>considerable</td>
<td>72;73;75</td>
</tr>
<tr>
<td>Race</td>
<td>Surgical resection</td>
<td>Higher income</td>
<td>1 out of 1</td>
<td>considerable</td>
<td>74</td>
</tr>
<tr>
<td>Preoperative quality of life</td>
<td>Postoperative mortality</td>
<td>Good preoperative QoL score</td>
<td>1 out of 1</td>
<td>minor</td>
<td>76</td>
</tr>
<tr>
<td>(good versus bad score)</td>
<td>Postoperative morbidity</td>
<td>--</td>
<td>0 out of 1</td>
<td>none</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>Survival</td>
<td>Good preoperative QoL score</td>
<td>4 out of 5</td>
<td>considerable</td>
<td>76-80</td>
</tr>
</tbody>
</table>
### Staging

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Purpose</th>
<th>Professional</th>
<th>Evidence</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT-scan</td>
<td>Detection of metastases</td>
<td>Experienced radiologist</td>
<td>1 out of 1</td>
<td>considerable</td>
</tr>
<tr>
<td>FDG-PET</td>
<td>Detection of metastases</td>
<td>Additional value of PET</td>
<td>8 out of 8</td>
<td>strong</td>
</tr>
<tr>
<td>EUS</td>
<td>Detection of metastases</td>
<td>High-volume EUS centre</td>
<td>1 out of 1</td>
<td>minor</td>
</tr>
</tbody>
</table>

### Neoadjuvant chemoradiation (yes versus no)

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postoperative mortality</td>
<td>No effect</td>
</tr>
<tr>
<td>Overall Survival</td>
<td>Neoadjuvant chemoradiation</td>
</tr>
<tr>
<td>Disease Free Survival</td>
<td>Neoadjuvant chemoradiation</td>
</tr>
</tbody>
</table>

### MDT management (yes versus no)

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survival</td>
<td>MDT management</td>
</tr>
</tbody>
</table>

### Surgical approach (transhiatal versus transthoracic)

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postoperative mortality</td>
<td>Transhiatal</td>
</tr>
<tr>
<td>Overall Survival</td>
<td>Transhiatal</td>
</tr>
</tbody>
</table>

### Thoracic Epidural (yes versus no)

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postoperative mortality</td>
<td>Thoracic epidural</td>
</tr>
<tr>
<td>Hospital stay</td>
<td>Thoracic epidural</td>
</tr>
</tbody>
</table>

### Pathology reporting

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accurateness of reporting</td>
<td>Proforma reporting</td>
</tr>
</tbody>
</table>

**Abbreviations:** QoL: quality of life; CT: computed tomography; FDG-PET: fluorodeoxyglucose positron emission tomography; EUS: endoscopic ultrasonography; MDT: multidisciplinary team

None: no evidence; minor: only evidence from univariate analysis; considerable: evidence from uni- and multivariate analysis; strong: evidence from several multivariate analyses or evidence from univariate analysis in 10 or more articles.
<table>
<thead>
<tr>
<th>Outcome measure</th>
<th>End point</th>
<th>Favouring</th>
<th>Nr of articles favouring</th>
<th>Level of evidence</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Duration of ICU-stay</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(≤ 5 days versus ≥6 days)</td>
<td>Survival</td>
<td>--</td>
<td>0 out of 1</td>
<td>none</td>
<td>119</td>
</tr>
<tr>
<td></td>
<td>Quality of life</td>
<td>--</td>
<td>0 out of 1</td>
<td>none</td>
<td>119</td>
</tr>
<tr>
<td><strong>Postoperative complication</strong></td>
<td>Postoperative mortality</td>
<td>No complication</td>
<td>2 out of 2</td>
<td>considerable</td>
<td>38;120</td>
</tr>
<tr>
<td>(yes versus no)</td>
<td>Postoperative ICU stay</td>
<td>No complication</td>
<td>1 out of 1</td>
<td>minor</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>Postoperative hospital stay</td>
<td>No complication</td>
<td>1 out of 1</td>
<td>minor</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>Costs</td>
<td>No complication</td>
<td>1 out of 1</td>
<td>considerable</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>Survival</td>
<td>No complication</td>
<td>2 out of 2</td>
<td>considerable</td>
<td>121;122</td>
</tr>
<tr>
<td><strong>(technical versus no complication)</strong></td>
<td>Postoperative mortality</td>
<td>No complication</td>
<td>3 out of 4</td>
<td>minor</td>
<td>123-126</td>
</tr>
<tr>
<td></td>
<td>Medical complications</td>
<td>No complication</td>
<td>3 out of 3</td>
<td>minor</td>
<td>123;124;126</td>
</tr>
<tr>
<td></td>
<td>Postoperative hospital stay</td>
<td>No complication</td>
<td>2 out of 2</td>
<td>minor</td>
<td>128;126</td>
</tr>
<tr>
<td></td>
<td>Survival</td>
<td>No complication</td>
<td>1 out of 2</td>
<td>considerable</td>
<td>129;124</td>
</tr>
<tr>
<td><strong>(pneumonia versus no pneumonia)</strong></td>
<td>Postoperative mortality</td>
<td>No pneumonia</td>
<td>3 out of 3</td>
<td>considerable</td>
<td>127-129</td>
</tr>
<tr>
<td></td>
<td>Survival</td>
<td>No pneumonia</td>
<td>1 out of 1</td>
<td>considerable</td>
<td>127</td>
</tr>
<tr>
<td><strong>Radicality of resection</strong></td>
<td>Survival</td>
<td>R0 resection</td>
<td>7 out of 8</td>
<td>strong</td>
<td>130-137</td>
</tr>
<tr>
<td><strong>(R0 versus R1 and R2)</strong></td>
<td>Survival</td>
<td>Higher nodal count</td>
<td>(ranging from &gt;23 to &gt;40)</td>
<td>strong</td>
<td>138-140</td>
</tr>
</tbody>
</table>

**Abbreviations:** ICU: Intensive Care Unit; R0: microscopically radical resection, R1: microscopically irradical resection; R2: macroscopically irradical resection

None: no evidence; minor: only evidence from univariate analysis; considerable: evidence from uni- and multivariate analysis; strong: evidence from several multivariate analyses or evidence from univariate analysis in 10 or more articles.
Pathology reporting

Histopathological assessment of the resection specimen plays an important role in patient management, in confirming whether complete excision has been achieved and in providing essential information on pathological tumour-node-metastasis (TNM) staging. The need to improve the quality of pathology reporting in oesophageal cancer management has been recognised.117,118

Outcome measures

Outcome variables with corresponding articles are listed in Table 3.

ICU stay

Length of ICU stay did not influence patients’ survival and long-term quality of life.119

Postoperative complications

The occurrence of postoperative complications after oesophageal cancer surgery has not only been associated with higher postoperative mortality rates and increased use of resources, but also with worse survival.38;120-129

Radicality of resection

Multiple studies130-136 have shown the independent prognostic value of a microscopically radical (R0) resection.130-137

Number of resected lymph nodes

The number of identified lymph nodes is an independent predictor of survival after oesophagectomy for cancer.138-140 According to Peyre et al, a minimum of 23 lymph nodes should be resected.140

‘Evidence-based’ quality indicators for oesophageal cancer surgery

A minimum dataset of ‘evidence-based’ quality-of-care indicators for the surgical treatment of oesophageal cancer was created based on the identified standards with strong evidence or those with considerable evidence in at least three articles. This dataset is presented in Table 4.
Table 4: ‘Evidence-based’ quality-of-care indicators for oesophageal cancer surgery

<table>
<thead>
<tr>
<th>Quality Indicator</th>
<th>End point</th>
<th>Favouring</th>
<th>Level of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STRUCTURAL MEASURES</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital volume (high- versus low-volume)</td>
<td>Postoperative mortality</td>
<td>High-volume hospital</td>
<td>Strong</td>
</tr>
<tr>
<td></td>
<td>Postoperative morbidity</td>
<td>High-volume hospital</td>
<td>Considerable</td>
</tr>
<tr>
<td></td>
<td>Postoperative hospital stay</td>
<td>High-volume hospital</td>
<td>Considerable</td>
</tr>
<tr>
<td></td>
<td>Costs</td>
<td>High-volume hospital</td>
<td>Considerable</td>
</tr>
<tr>
<td>Surgeon volume (high- versus low-volume)</td>
<td>Postoperative morbidity</td>
<td>High-volume surgeon</td>
<td>Strong</td>
</tr>
<tr>
<td><strong>PROCESS MEASURES</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (&lt; 70 years versus &gt; 70 years)</td>
<td>Postoperative mortality</td>
<td>No age limit</td>
<td>Strong</td>
</tr>
<tr>
<td></td>
<td>Survival</td>
<td>No age limit</td>
<td>Strong</td>
</tr>
<tr>
<td>Preoperative quality of life (good versus bad score)</td>
<td>Survival</td>
<td>Good preoperative score</td>
<td>Considerable</td>
</tr>
<tr>
<td><strong>STAGING</strong> (FDG-PET versus no FDG-PET)</td>
<td>Detection of metastases</td>
<td>Additional value of PET</td>
<td>Strong</td>
</tr>
<tr>
<td>Neoadjuvant chemoradiation (yes versus no)</td>
<td>Postoperative mortality</td>
<td>No effect</td>
<td>Strong</td>
</tr>
<tr>
<td></td>
<td>Postoperative morbidity</td>
<td>No effect</td>
<td>Strong</td>
</tr>
<tr>
<td>Surgical approach (transhiatal versus transthoracic)</td>
<td>Postoperative morbidity</td>
<td>Transhiatal</td>
<td>Considerable</td>
</tr>
<tr>
<td><strong>OUTCOME MEASURES</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postoperative complication (yes versus no)</td>
<td>Survival</td>
<td>No complication</td>
<td>Considerable</td>
</tr>
<tr>
<td></td>
<td>Postoperative mortality (pneumonia versus no pneumonia)</td>
<td>No pneumonia</td>
<td>Considerable</td>
</tr>
<tr>
<td>Radicability of resection (R0 versus R1 and R2)</td>
<td>Survival</td>
<td>R0 resection</td>
<td>Strong</td>
</tr>
<tr>
<td>Number of resected lymph nodes (high versus low)</td>
<td>Survival</td>
<td>Higher nodal count (ranging from &gt;23 to &gt;40)</td>
<td>Strong</td>
</tr>
</tbody>
</table>

Abbreviations: FDG-PET: fluorodeoxyglucose positron emission tomography; R0: microscopically radical resection; R1: microscopically irradical resection; R2: macroscopically irradical resection
Considerable: evidence from uni- and multivariate analysis in 3 or more articles; strong: evidence from several multivariate analyses or evidence from univariate analysis in 10 or more articles.
Discussion

This has been the first review of the literature to identify evidence-based standards for high-level quality of care for oesophageal cancer patients who are candidates for surgery. Results show that (1) there is strong evidence that both hospital and surgeon volume are important determinants for postoperative mortality, (2) other structural measures, e.g., infrastructure and organization of oesophageal cancer surgery, have been less frequently investigated, (3) the most commonly reported process measures were determinants of patient selection for surgery (e.g., patients' age), (4) other process indicators with considerable evidence were found (e.g., multidisciplinary team management), though the number of studies was small, and (5) the level of evidence for pathological outcome measures was high.

Structural measures

A plethora of studies concerning the volume-outcome relationship for oesophageal cancer surgery was found. High-volume and specialized care were mostly related to a decreased postoperative mortality, and, in a lesser extent, to lower postoperative morbidity, shorter hospital stay, better survival and lower costs. Volume is only a surrogate for high-level processes of care and does not reveal the mechanisms behind the better outcomes. There is evidence that centralization of oesophageal cancer resections leads to substantial improvements in outcome. Such efforts have been accompanied by continuous measurement and feedback of process and outcome indicators to individual surgeons and their referring colleagues. Only then, improvements in outcome are to be expected.9 Data on infrastructural or organizational characteristics that lead to success or failure, were very limited (e.g., ICU staffing) or absent (e.g., ICU level).

Process measures

Evidence was found that teams using a risk score for the selection of surgical patients can decrease their postoperative mortality rates.67 Several risk-prediction models have been proposed for this purpose, such as the Physiologic and Operative Severity Score for the enumeration of Mortality and morbidity (O-POSSUM).141 The O-POSSUM has only been studied retrospectively showing a two- or three-fold overprediction of in-hospital mortality.142-144 Steyerberg et al developed a more simple risk score, that also included the excess risk on postoperative mortality introduced by operations performed in low-volume hospitals.145 Again, this risk score could not be validated by others.146,147

Age, nutritional or socio-economic status should not be used as selection criteria for oesophageal cancer surgery. On the other hand, in assessing resection rates or surgical outcome, these factors are to be included as case-mix variables. Preoperative feeding to
prevent further deterioration of the nutritional state of patients presenting with obstructive symptoms and weight loss could be a valid quality indicator, but the level of evidence for a better outcome is low.\textsuperscript{59}

We found evidence –although limited- that volume and experience play a role in the staging process of patients with oesophageal cancer.\textsuperscript{91,90} It would be better to assess the whole staging process by calculating the percentage of patients in whom a futile operation has been performed due to inadequate staging.

Neoadjuvant chemoradiation followed by surgery was associated with similar postoperative mortality rates as surgery alone in all studies, and survival rates improved in two studies.\textsuperscript{84,105} If neoadjuvant chemoradiation becomes standard of care, there is a need to formulate quality indicators for its use (e.g., toxicity criteria).

Diagnosis and treatment of oesophageal cancer patients by a dedicated multidisciplinary team could be an important quality indicator, but this is supported by only one paper.\textsuperscript{108} Not only the expertise of the surgeon, but also that of the radiologist, anaesthesiologist, ICU-physician and nurses contribute to the outcome of surgery.

There is considerable evidence that the transhiatal approach leads to a reduced postoperative morbidity rate.\textsuperscript{109-112} Presumed that the transthoracic approach with an extended lymphadenectomy is technically more challenging, one could propose that the performance of transthoracic oesophagectomies in patients with a tumour located in the distal oesophagus should be regarded as a quality indicator.

No studies were found on other process indicators such as waiting times or psychological guidance during treatment.

**Outcome measures**
Outcome measures, like postoperative complication rates, tumour negative surgical margins, and number of retrieved lymph nodes are plausible measures of quality of care for physicians and their patients.

Further investigation is warranted to look for additional valid outcome parameters of quality of care (e.g., hospital readmission rates, pain scores, number of anastomotic dilatations).

**Limitations**
A major limitation to this review is that there is no MESH term for “quality of care”. We have tried to give an overview of the available literature on evidence-based determinants for high-leverage quality of care, but our review may have been biased by the choice of our search terms. Secondly, case-mix plays an important role in evaluating differences in outcome after oesophageal cancer surgery. Consequently, for many studies, with a lack
of information on patients’ co-morbidity, tumour stage distribution, and patient selection criteria, the conclusions are debatable.

**Future directions**

The uniform use of well-defined quality-of-care indicators to measure and document practice performance holds the promise of improving outcomes in patients who undergo surgical treatment for oesophageal cancer. Recently, another evidence-based review of oesophageal cancer surgery was published. In this review, non-surgical issues were not addressed. The present review places oesophageal cancer surgery in a broader perspective. Improving the level of care for surgical oesophageal cancer patients is a team effort from diagnosis, staging and risk assessment to follow-up and management of late sequelae of treatment. Ideally, each step is monitored by a set of measurable elements which reflect the quality of care.

Several projects have been started in which quality indicators are to be developed, not only based on evidence from the literature, but also on consensus of experts in the field. In Denmark, the Danish National Indicator Project has shown that continuous performance and outcome measurement, using clinical indicators is possible and fruitful in terms of quality improvement. Recently, Bilimoria et al presented an extensive set of quality indicators for pancreatic cancer. After reviewing the literature for potential quality indicators, a Delphi method was used to develop quality indicators consulting several expert panels. In our opinion, a similar procedure should be pursued for oesophageal cancer care. To benchmark the outcome of consensus-based quality indicators, multi-centred data-collection, data-analysis and feedback of individual data is essential to provide physicians with actionable information about their quality of care.


32. Kazui T, Osada H, Fujita H. An attempt to analyze the relation between hospital surgical volume and clinical outcome. Gen Thorac


