Quality of Life After Stereotactic Body Radiation Therapy or Surgery for Early-Stage NSCLC: A Systematic Review

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Received 18 August 2022; revised 16 September 2022; accepted 19 September 2022
Available online - 22 September 2022

ABSTRACT

Quality of life (QOL) is a key consideration for patients with early-stage NSCLC choosing between treatment options. Currently, it is not well established whether stereotactic body radiation therapy (SBRT) or surgery offers superior QOL in early-stage NSCLC. The objective of this systematic review is to summarize the prospective literature on QOL in patients with early-stage NSCLC after treatment with SBRT or surgery. A comprehensive literature review using PubMed and EMBASE was performed in April 2022. Prospective studies evaluating QOL data across multiple time points in patients with early-stage NSCLC after SBRT or surgery were included. A total of 25 studies involving 1597 SBRT patients and 1652 surgery patients met the inclusion criteria. Across most studies, QOL remained stable after treatment with SBRT. After surgery, QOL initially decreased; however, it often returned to baseline in the next 6 to 12 months. Utilization of video-assisted thoracoscopic surgery and sublobar resection reduced the magnitude of the initial decrease in QOL after surgery and led to faster recovery to baseline. Owing to the heterogeneity of patient populations between studies evaluating SBRT versus surgery, direct comparisons between the two treatments remain difficult to make. Clinicians should appropriately counsel patients with this information to help guide patient-centered discussions on choosing the optimal treatment modality.

Keywords: Lung cancer; Systematic review; Quality of life; SBRT; NSCLC; Surgery

Introduction

Lung cancer is the leading cause of cancer-related death worldwide and approximately 80% of lung cancers are diagnosed as NSCLC.1 Following the implementation of the U.S. Preventive Services Task Force recommendation for low-dose computed tomography screening of lung cancer, there has been a steady increase in the proportion of patients diagnosed with having lung cancer at an early-stage.2,3 Earlier diagnosis has led to improved survival in this population, making quality of life (QOL) for these patients an important consideration when choosing the optimal treatment. Compared with age-matched controls in the general

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Disclosure: The authors declare no conflict of interest.

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Cite this article as: Iovoli AJ, Yu B, Ma SJ, et al. Quality of life after stereotactic body radiation therapy or surgery for early-stage NSCLC: a systematic review. JTO Clin Res Rep. 2022;3:100417.

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ISSN: 2666-3643
https://doi.org/10.1016/j.jtocrr.2022.100417

JTO Clinical and Research Reports Vol. 3 No. 11: 100417
population, lung cancer survivors have a clinically meaningful decrease in global QOL.4

Current guidelines of the National Comprehensive Cancer Network recommend surgical resection as first-line management of operable early-stage NSCLC, with stereotactic body radiation therapy (SBRT) recommended for patients considered medically inoperable.5 Despite these recommendations, it is unclear whether surgery or SBRT provides better clinical outcomes. Previous trials comparing surgery and SBRT for operable patients, including the American College of Surgeons Oncology Group Z4099, the ROSEL trial, and the STARS trial, had difficulty with patient accrual and were inconclusive.6–8 To answer this unsettled question, several ongoing randomized trials including STABLE-MATES and VALOR are evaluating surgery versus SBRT for early-stage NSCLC. Unfortunately, these data will not be available soon. A recent propensity-matched comparison of SBRT and surgical patients found that SBRT was noninferior.9

Alongside oncologic outcomes, QOL is a key consideration for patients with early-stage NSCLC, which may affect clinical decision making. Currently, it is not well established whether SBRT or surgery offers superior QOL in this population. To address this knowledge gap, we performed a systematic review of the current prospective literature on QOL after treatment with SBRT or surgery in patients with early-stage NSCLC.

Methods

This review was performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.10 A comprehensive literature review using PubMed and EMBASE was performed without automation using keywords “lung cancer,” “NSCLC,” “SBRT,” “Stereotactic body radiation therapy,” “SABR,” “Stereotactic ablative radiotherapy,” “radiation,” “radiotherapy,” “surgery,” “pulmonary resection,” “pneumonectomy,” “thoracotomy,” “lobectomy,” “resection,” and “treatment.” Filters were applied to only include clinical studies, clinical trials, observational studies, and randomized controlled trials. The literature review was performed in April 2022. This systematic review was not registered.

Inclusion Criteria

Inclusion criteria was as follows: (1) prospective studies; (2) baseline QOL data and QOL data for at least one time point after treatment; (3) includes patients with early-stage NSCLC as a stratified group; (4) treatment with SBRT or surgery; and (5) written in English. Early-stage NSCLC was defined as American Joint Committee on Cancer Eight edition T1–2N0M0. If multiple analyses of a randomized control trial were found, only the most relevant analysis was included in this study.

Data Extraction

Three reviewers independently screened the search results based on title, and relevant titles underwent full-text review. Data including study design, participant demographics, treatment modality, QOL tools, and findings were extracted by two reviewers and recorded on a standardized electronic data collection sheet. Aggregate data were used in place of individual patient data. For the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire—Core 30 (QLQ-C30), clinical significance for QOL change was defined as more than or equal to 10 points.11 The data were synthesized in a narrative approach. Owing to heterogeneity in the surveys used across the included studies, a meta-analysis was not performed.

Quality Assessment

Two reviewers evaluated the methodological quality of each article using the standardized 14-item checklist of predefined criteria defined by Mols et al.12 The checklist included criteria on evaluating methodology and reporting of results. Each criterion satisfied was assigned one point, with the highest possible score being 14. Studies with a total of at least 11 points (≥75% of maximum score) were considered as “high quality.” Studies with a total of 50% to 75% of the maximum score were rated as “moderate quality.” Studies with less than 50% criteria satisfied were scored as “low quality.”

Results

A total of 25 prospective studies met the inclusion criteria and were included in this study for analysis.6,13–36 Publication years ranged from 2003 to 2022. The PRISM decision tree is illustrated in Figure 1. Studies were separated into categories based on whether they contained QOL data for SBRT alone, surgery alone, or SBRT and surgery.

Studies Evaluating QOL After SBRT

Table 1 summarizes the characteristics and outcomes for studies evaluating SBRT alone.15–19,21,22,24,25,28,36 All patients in the 11 studies were diagnosed with having T1–2N0M0 NSCLC and considered medically inoperable or refused surgery. Only patients receiving SBRT were included (two studies compared QOL in patients receiving SBRT or three-dimensional conformal radiotherapy). The median number of patients was 49 and median age of patients was 76 years. Dose fractionation
varied from as few as 30 Gy in a single fraction to 60 Gy in eight fractions. QOL tools used included most often the QLQ-C30 with its associated lung cancer module (LC-13) or the Functional Assessment of Cancer Therapy—Lung (FACT-L) instrument. Other QOL tools included the Lung Cancer Symptom Scale and the EuroQoL Group 5D.

**Studies Evaluating QOL After Surgery**

Table 2 summarizes the characteristics and outcomes for studies evaluating QOL after surgery alone. All patients in the nine studies were diagnosed with having stage I or II NSCLC. The median number of patients was 173 and median age of patients was 67 years. Surgical techniques varied between studies and included open thoracotomy, video-assisted thoracoscopic surgery (VATS), and robotic-assisted thoracoscopic surgery. Extent of resection also varied between studies and included pneumonectomy (in one study), lobectomy, and sublobar resections. One study evaluated the addition of brachytherapy to sublobar resection. The most common QOL tool used was the QLQ-C30 and LC-13 instrument. Others used included the FACT-L, EuroQoL Group 5D, Short-Form Health Survey 36, and Leicester Cough Questionnaire.

**Studies Evaluating QOL After SBRT and Surgery**

Table 3 summarizes the characteristics and outcomes for studies evaluating QOL in both SBRT and surgery. All patients in the five studies were diagnosed with having early-stage NSCLC. One of these studies evaluated QOL in patients treated with SBRT followed by surgery and was not a comparison between the two. The median number of patients was 127 and median age of patients receiving SBRT versus surgery was 73.5 years and 67 years, respectively. QOL tools used included the QLQ-C30, LC-13, FACT-L, and EuroQoL Group 5D.

Among studies using the most common QOL tool (QLQ-C30), the average baseline global QOL score for SBRT patient cohorts was 63.9 (SD = 5.9) and for surgery patient cohorts was 69.8 (SD = 8.3). Two studies...
## Table 1. Study Characteristics and Selected Quality of Life Findings for Treatment of Early-Stage NSCLC With SBRT

| Study                  | Location     | N     | Age (Median) | Dose/Fx | QOL Tool(s) | Assessments          | Selected Findings                                                      | Study Quality |
|------------------------|--------------|-------|--------------|---------|-------------|-----------------------|-----------------------------------------------------------------------|---------------|
| van der Voort et al., 2010 | The Netherlands | 39    | 77           | 60/3 48-50/5-6 45/3 | QLQ-C30, LC-13 | BL, 3 wk, 2, 4, 6, 9, 12 mo | Emotional functioning improved 17% after SBRT, remaining QOL domains stable | 11            |
| Widder et al., 2011    | The Netherlands | 202   | 76           | 60/3 60/5 60/8 | QLQ-C30, LC-13 | BL, 3, 6, 12, 24 mo | QOL stable after SBRT                                                | 11            |
| Lagerwaard et al., 2012 | The Netherlands | 382   | 74           | 60/3 60/5 60/8 | QLQ-C30, LC-13 | BL, 3, 6, 12, 18, 24 mo | QOL stable after SBRT                                                | 11            |
| Videtic et al., 2013   | USA          | 21    | 77           | 60/3 50/5 | FACT-L | BL, 6 wk, 3, 6, 9, 12 mo | QOL stable after SBRT                                                | 11            |
| Sun et al., 2014       | USA          | 19    | 74           | 50-60/5 | FACT-L FACIT-sp-12 | BL, 6, 12 wk | QOL stable after SBRT                                               | 10            |
| Ferrero et al., 2015   | Italy        | 30    | 77           | 45-54/3 55/5 60/8 | LCSS | BL, 45, 135, 225, 315 d | Fatigue increased 37% 9 mo after SBRT, remaining QOL domains stable   | 10            |
| Mathieu et al., 2015   | Canada       | 45    | 77           | 60/3 50/4-5 | QLQ-C30, LC-13 | BL, last Fx, 2, 6, 12, 24, 36 mo | QOL and pulmonary function stable after SBRT                           | 12            |
| Nyman et al., 2016     | Sweden       | 49    | 73           | 66/3    | QLQ-C30, LC-14 | BL, 7 wk, 6, 12 mo | QOL stable after SBRT                                                | 11            |
| Rutkowski et al., 2017 | Poland       | 51    | 74           | NR      | QLQ-C30, LC-13, HADS | BL, 2 wk, 3 mo | Emotional functioning improved 12% and insomnia decreased 41% at 3 mo after SBRT, remaining QOL domains stable | 11            |
| Jeppesen et al., 2018  | Denmark      | 51    | 72           | 45-66/3 | EQ-5D | BL, 5 wk, 3, 6, 9, 12 mo | QOL stable after SBRT                                                | 11            |
| Singh et al., 2019     | USA          | 98    | 76           | 30/1 60/3 | QLQ-C30, LC-13 | BL, 6 mo | QOL stable after SBRT, one fraction SBRT had improved social functioning and dyspnea compared with three fraction SBRT | 12            |

*Study quality was determined using the standardized 14-item checklist of predefined criteria defined by Mols et al.*

BL, baseline; EQ-5D, EuroQoL Group 5D; FACIT-sp-12, Functional Assessment of Chronic Illness Therapy - Spiritual Well-Being 12 Item Scale; FACT-L, Functional Assessment of Cancer Therapy-Lung; Fx, fractions; HADS, Hospital Anxiety and Depression Scale; LC-13, Lung Cancer Module; LCSS, Lung Cancer Symptom Scale; NR, not reported; QLQ-C30, European Organization for Research and Treatment of Cancer Quality of Life Questionnaire—Core 30; QOL, quality of life; USA, United States of America.
### Table 2. Study Characteristics and Selected Quality of Life Findings for Treatment of Early-Stage NSCLC With Surgery

| Study                  | Location      | N  | Surgery Type | Surgery Extent | Age (Median) | Stage | QOL Tool(s) | Assessments       | Selected Findings                                                                                   | Study Quality |
|------------------------|---------------|----|--------------|----------------|--------------|-------|-------------|-------------------|----------------------------------------------------------------------------------------------------|---------------|
| Pompeo et al., 2003    | Italy         | 16 | VATS: 63%    | LR: 37%         | 65           | I     | SF-36       | BL, 6, 12, 18, 24, 30, 36 mo | General QOL improved by 41% and physical functioning improved by 56% at 6 mo after surgery            | 13            |
| Kenny et al., 2007     | Australia     | 173| TR: 100%     | PR: 25%         | 66           | I-II  | QLQ-C30, LC-13 | BL, DC, 1, 4, 8, 12, 16, 20, 24 mo | General QOL declined by 39% after surgery at discharge; persistent 8% decline at 24 mo               | 11            |
| Fernando et al., 2015  | USA           | 212| NR           | SLR: 100%       | 71           | IA    | SF-36, SOBQ | BL, 3, 12, 24 mo | QOL stable after SLR with or without the addition of brachytherapy                                  | 12            |
| Bendixen et al., 2016  | Denmark       | 106| VATS: 50%    | LR: 100%        | 66           | I     | QLQ-C30, EQ-5D | BL, 2, 4, 8, 12, 26, 52 wk | Physical QOL declined by 13% at 2 wk after VATS and 22% after TR; both recovered to baseline by 12 wk | 11            |
| Stamatis et al., 2019  | Germany       | 108| VATS: 33%    | LR: 50%         | 68           | IA    | QLQ-C30, LC-13 | BL, DC, 6 wk, 3, 6, 12 mo | General QOL declined by 27% after surgery at discharge; QOL recovered to baseline by 6 mo in SLR group and by 12 mo in LR group | 10            |
| Marzorati et al., 2020 | Italy         | 176|RATS: 34%     | LR: 100%        | 67           | I-II  | QLQ-C30     | BL, 1, 4, 8, 12 mo | General QOL recovered by 17% from 1 to 12 mo after surgery                                          | 11            |
| Février et al., 2020   | USA           | 201| VATS: 100%   | LR: 37%         | 68           | IA    | FACT-L, SF-12, PHQ-9 | BL, 4, 6, 12 mo | Physical QOL declined by 18% after LR and 6% after SLR at 2 mo; both recovered to baseline at 12 mo | 10            |
| Novellis et al., 2021  | Italy         | 169|RATS: 34%     | NR              | 69           | I-II  | QLQ-C30, LC-13 | BL, DC, 2 wk, 6, 12 mo | General QOL declined 21% after RATS, 19% after VATS, and 42% after TR 2 wk; recovered to baseline at 6 mo after RATS and VATS; persistent 32% decline at 12 mo after TR | 9             |
| Lin et al., 2022       | People's Republic of China | 156| VATS: 100%   | LR: 58%         | 58           | I     | LCQ         | BL, DC, 1, 3, 6 mo | General QOL declined 24% after surgery at discharge, with recovery back to baseline at 6 mo; faster recovery noted after SLR over LR | 11            |

*Study quality was determined using the standardized 14-item checklist of predefined criteria defined by Mols et al. [12]*

BL, baseline; DC, discharge; EQ-5D, EuroQol Group 5D; FACT-L, Functional Assessment of Cancer Therapy-Lung; LC-13, Lung Cancer Module; LCQ, Leicester Cough Questionnaire; LR, lobectomy; NR, not reported; PHQ-9, Patient Health Questionnaire-9; PR, pneumonectomy; QLQ-C30, European Organization for Research and Treatment of Cancer Quality of Life Questionnaire—Core 30; QOL, quality of life; RATS, robotic-assisted thoracoscopic surgery; SF-36, Short-Form Health Survey 36; SLR, sublobar resection; SOBQ, San Diego Shortness of Breath Questionnaire; TR, thoracotomy; VATS, video-assisted thoracoscopic surgery.
| Study                  | Location       | N      | Age (Median) | Surgery Type | Surgery Extent | Dose/Fx | QOL Tool(s) | Assessments | Selected Findings                                                                 |
|-----------------------|----------------|--------|--------------|--------------|----------------|---------|-------------|-------------|----------------------------------------------------------------------------------|
| Louie et al., 2015    | The Netherlands| 11 SBRT 11 Surgery | 65 SBRT 65 Surgery | NR           | LR: 91% SLR: 9% | 54/3 60/5 | QLQ-C30 LC-13 EQ-5D | BL, 3, 6, 12, 18, 24 mo | QOL stable after SBRT; persistent 15% decline in general QOL at 12 mo after surgery |
| Wolf et al., 2018     | The Netherlands| 40 SBRT 41 Surgery | 74 SBRT 67 Surgery | VATS: 12% TR: 88% | LR: 78% SLR: 3% | 54 60/3 60/5 60/8 | QLQ-C30 | BL, 3, 6, 9, 12 mo | QOL stable after SBRT and surgery at 12 mo                                        |
| Palma et al., 2019    | Canada         | 40 SBRT + Surgery | 68            | VATS: 81% TR: 19% | LR: 72% SLR: 28% | 54/3 55/5 60/8 | FACT-L | BL, 8 wk, 3, 9 mo | Persistent physical QOL decline of 6% at 9 mo after SBRT plus surgery             |
| Nugent et al., 2020   | USA            | 74 SBRT 53 Surgery | 73 SBRT 67 Surgery | VATS: 68% TR: 15% | LR: 89% SLR: 11% | 55.2 (mean) | QLQ-C30 LC-13 FACT-L SGRQ | BL, DC, 4-6 wk, 6, 12 mo | General QOL decline of 12% after surgery at discharge; persistent QOL declines in 30% of both SBRT and surgery patients at 12 mo |
| Pompili et al., 2021  | UK             | 95 SBRT 130 VATS | 74 SBRT 70 VATS | VATS: 100% NR | NR | QLQ-C30 LC-13 | BL, 6 wk, 3, 6, 12 mo | QOL stable after SBRT; persistent 10% global QOL decline after surgery at 12 mo |

aStudy quality was determined using the standardized 14-item checklist of predefined criteria defined by Mols et al.12

BL, baseline; DC, discharge; EQ-5D, EuroQol Group 5D; FACT-L, Functional Assessment of Cancer Therapy-Lung; Fx, fractions; LC-13, Lung Cancer Module; LR, lobectomy; NR, not reported; QLQ-C30, European Organization for Research and Treatment of Cancer Quality of Life Questionnaire—Core 30; QOL, quality of life; SLR, sublobar resection; TR, thoracotomy; UK, United Kingdom; USA, United States of America; VATS, video-assisted thoracoscopic surgery.
SBRT, which may be attributed to patients undergoing lung SBRT have consistently stable baseline in QOL after surgery and led to faster recovery to VATS and sublobar resection reduced the initial decline after an initial reduction for most patients. Utilization of SBRT and that after surgery, QOL returns to baseline provides support that QOL outcomes are favorable after management of early-stage NSCLC. This systematic review important consideration during patient-centered man-

Methodological Quality
Quality scores are found in Tables 1 to 3. The mean quality score was 10.9 (range: 9–13). A total of 18 studies had a score of at least 11 and were considered high quality. The remaining seven studies had moderate quality. The prevailing methodological shortcomings were unreported follow-up time, low survey response rate, and incomplete patient selection data. Aggregate patient compliance for SBRT and surgery cohorts is found in Figure 2.

Discussion
The impact of treatment choice on QOL should be an important consideration during patient-centered management of early-stage NSCLC. This systematic review provides support that QOL outcomes are favorable after SBRT and that after surgery, QOL returns to baseline after an initial reduction for most patients. Utilization of VATS and sublobar resection reduced the initial decline in QOL after surgery and led to faster recovery to baseline.

Of 14 studies in this review, 13 provide evidence that patients undergoing lung SBRT have consistently stable QOL after the treatment. Two studies revealed improvement in emotional functioning domains and one revealed a decrease in nervousness and worry after SBRT, which may be attributed to patients' satisfaction with good local control outcomes coupled with the low toxicity of treatment. Two studies identified an increase in dyspnea after SBRT, one at 3-month follow-up and the other at 6-month follow-up, which rebounded at subsequent clinic visits and remained stable. These findings could be explained by the development of radiation pneumonitis. Widder et al. did report a statistically significant increase in dyspnea after SBRT, but given the small magnitude of effect, this was felt to be clinically insignificant. In regard to pulmonary functioning, there were two studies that revealed pulmonary function was stable after SBRT whereas one revealed a decline in slow vital capacity, forced expiratory volume in 1 second, diffusing capacity of the lungs for carbon monoxide, and partial pressure of oxygen at 135 days. Singh et al. compared QOL between patients randomized to different dose-fractionation regimens and found that single-fraction SBRT had improved social functioning and dyspnea in comparison to three-fraction SBRT. No other SBRT studies identified changes in lung cancer-related symptoms. That of Nugent et al. was the only study to note a decrease in QOL from baseline in 30% of lung SBRT patients. The findings from this review are in agreement with a previous systematic review that found lung SBRT was well tolerated overall.

After surgery for early-stage NSCLC, all 10 studies that included a QOL assessment within 2 months of surgery revealed an initial decline in QOL at the first postoperative time point, which ranged from 6% to 42% depending on surgical technique and QOL instrument used. In five of these studies, QOL rebounded back to baseline by 6 to 12 months, and in the other five, there was a persistent decline in QOL. Of the studies that included a dyspnea assessment after surgery, dyspnea worsened postoperatively in seven of nine trials and at 1 to 2 years of follow-up was persistently worse in five of them. Kenny et al. revealed a substantial QOL decrease after surgery that recovered in only 50% of patients; however, this study was the only one to include a high pneumonectomy rate (25%), which may explain the poorer QOL outcomes compared with others. Pompili et al. reported that role function, pain, dyspnea, and alopecia remained lower than baseline by a clinically meaningful amount at 12 months after surgery. Two studies reported stable QOL at all time points after surgery; however, the first postoperative assessment was not until 3 months for each, which likely failed to capture an initial postoperative decline. That of Pompeo et al. was the only study to reveal an improvement in QOL after surgery; however, this small study was limited to a selected group of patients with severe emphysema receiving a concurrent lung volume reduction surgery.
In regard to operative approach, a systematic review of 15 studies comparing QOL after minimally invasive versus open thoracotomy approaches found minimally invasive techniques to be associated with improved QOL during recovery, particularly in regard to physical functioning and pain. This is consistent with the results of our review, which found that in four of five surgical studies with a VATS cohort, QOL recovered to baseline. Contrasting this, in two of three studies with an open thoracotomy cohort, QOL was persistently reduced at 1 to 2 years of follow-up.

Extent of surgical resection was also associated with QOL outcomes. One study found that sublobar resection was associated with less of an initial QOL decline after surgery in comparison with lobectomy. Two studies found that sublobar resection was associated with a faster QOL recovery back to baseline in comparison to lobectomy. These findings are important in the context of emerging randomized trial data that suggest sublobar resection is noninferior to lobectomy in appropriately selected patients with early-stage NSCLC.

Four studies evaluated and compared both SBRT and surgery patient cohorts; however, baseline patient characteristics were inherently different between the groups in three of them. As is often the case in clinical practice, patients receiving SBRT tended to be older, have more medical comorbidities, and have worse baseline QOL compared with patients undergoing surgery. Patients with more comorbidities may be less likely to have symptoms improved by treatment and more likely to have worsening of QOL with treatment-related side effects. This heterogeneity limits the conclusions that can be drawn from comparisons between SBRT and surgery patient cohorts lacking randomization. Despite these challenges, two studies comparing cohorts of patients undergoing SBRT or surgery found QOL to be similar after both, with one noting a 30% decrease from baseline in both groups. These findings are consistent with a SEER study that found both SBRT and surgery negatively affected QOL with no significant difference in the change over time between the two treatment options. In the only reported randomized study comparing QOL between SBRT and surgery, Louie et al. found global health status to be improved in the SBRT patients. Although QOL comparison between SBRT and surgery in the existing literature is problematic owing to the heterogeneity of patient populations, both modalities seem to offer comparable QOL outcomes with a small signal favoring SBRT in the report by Louie et al. as revealed by global health status improvement, albeit with a small sample size.

QOL metrics for patients undergoing treatment for early-stage NSCLC can also provide valuable data informing prognosis. For patients undergoing SBRT, prerradiation QOL metrics such as physical role and emotional functioning were found to be associated with risk of mortality. Another study found that changes in global health status, functional QOL, or symptom burden after SBRT as described by principle component analysis values were associated with overall survival. Similarly, for surgical patients, a poor global health status before surgery for lung cancer was found to be associated with increased postoperative cardiopulmonary morbidity. Emphasizing the importance of QOL in patient-centered decision making, one study found for patients with early-stage lung cancer that maintaining independence and QOL were more highly valued than survival or cancer recurrence. Patients diagnosed with having early-stage NSCLC should undergo multidisciplinary discussion and be appropriately counseled on the benefits and risks of all treatment options, including both surgery and SBRT.

Limitations

The main limitation of this review is the heterogeneity between SBRT and surgery patient cohorts as previously described. Furthermore, within the cohort of patients undergoing surgery, there was heterogeneity in surgical technique and extent of resection that was found to influence QOL outcomes. Another limitation is the variety in QOL tools used between studies, as it is known that these different tools do not measure the same dimensions in the same way.

More than half of the included studies were limited by low survey response rates which may weaken the generalizability of the results. This can introduce bias of QOL overestimation because attrition of QOL longitudinal evaluation is not a random effect but primarily affects patients with the lowest QOL. Ongoing trials randomizing patients to SBRT or surgery such as STABLE-MATES and VALOR will provide valuable information to overcome many of the limitations in the current literature. Future clinical trials evaluating early-stage NSCLC should incorporate QOL data collection to inform the development of clinical decision-making tools.

Conclusions

For early-stage NSCLC, QOL outcomes are favorable after SBRT. Nevertheless, after surgery, QOL initially declines and then returns to baseline in 6 to 12 months for most patients. Utilization of VATS and sublobar resection reduces the initial decline in QOL after surgery and can lead to faster recovery to baseline. Owing to the heterogeneity of patient populations between studies evaluating SBRT versus surgery, direct comparison
between the two treatments remains difficult to make. Further randomized trial data comparing SBRT and surgery are needed to better inform clinical decision making.

**CRediT Authorship Contribution**

**Austin J. Iovoli:** Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Visualization.

**Brian Yu:** Methodology, Investigation, Writing – review & editing.

**Sung Jun Ma:** Methodology, Investigation, Writing – review & editing.

**Mark K. Farrugia, Elizabeth U. Dexter, Sai Yendamuri, Elizabeth G. Bouchard:** Writing – review & editing.

**Anurag K. Singh:** Conceptualization, Methodology, Validation, Supervision.

**Data Sharing**

Research data are stored in an institutional repository and will be shared on request to the corresponding author.

**Acknowledgments**

This research was supported by the National Cancer Institute Cancer Center Support Grant (P30CA016056). The sponsors had no role in this systematic review.

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