

Advanced Squamous Cell Carcinoma of the Lung: Current Treatment Approaches and the Role of Afatinib

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Edgardo S Santos¹
Lowell Hart^{2,3}

¹Florida Precision Oncology/A Division of 21st Century Oncology, Florida Atlantic University, Aventura, FL, USA; ²Drug Development Unit, Florida Cancer Specialists, Fort Myers, FL, USA; ³Wake Forest School of Medicine, Winston-Salem, NC, USA

Abstract: Options for the treatment of squamous cell lung carcinoma expanded in recent years with the introduction of the immune checkpoint inhibitors into routine clinical practice in both the first- and second-line settings but are still limited. As a result, pembrolizumab, given either alone or in combination with platinum-based chemotherapy, is now a standard first-line treatment for squamous cell lung cancer. However, few options exist once patients have progressed on immune checkpoint inhibitors and chemotherapy. In this setting, the irreversible ErbB family blocker, afatinib, has a potential role as second or subsequent therapy for some patients. The Phase III LUX-Lung 8 study demonstrated that afatinib significantly prolonged progression-free and overall survival compared with erlotinib in patients with squamous cell lung carcinoma. Notably, retrospective, ad-hoc biomarker analyses of a subset of patients from LUX-Lung 8 suggested that patients with ErbB family mutations derived particular benefit from afatinib, especially those with *ErbB2* (*HER2*) mutations. Afatinib has a manageable and predictable safety profile, and adverse events can be managed with the use of a tolerability-guided dose modification protocol. Until more data are available, afatinib could be considered as a potential second-line treatment option for patients who have progressed on combined pembrolizumab and platinum-based chemotherapy and are ineligible for more established second-line options, or as a third-line option in patients who have received first-line immunotherapy, and second-line chemotherapy or chemotherapy and antiangiogenesis therapy. However, further data are required to support the use of afatinib following immunotherapy. Given that treatment options are limited in both of these settings, investigating an agent with an entirely new mechanism of action is warranted. If available, molecular analysis to identify ErbB family mutations or the use of proteomic profiling could help to further isolate patients who are likely to derive the most benefit from afatinib.

Keywords: EGFR, NSCLC, second-line therapy, sequencing

Plain Language Summary

Patients who have just been diagnosed with the type of non-small-cell lung cancer (NSCLC) known as squamous NSCLC usually receive chemotherapy or an immune checkpoint inhibitor (for example, pembrolizumab). Immune checkpoint inhibitors may be given either alone or in combination. For patients who have stopped responding to immune checkpoint inhibitors and chemotherapy, alternative treatments are limited and needed. One possible option is afatinib, an orally administered drug that specifically targets a receptor in the cell membrane of the tumor cell, called the epidermal growth factor receptor (EGFR). In a large clinical study, patients receiving afatinib lived for longer without disease progression than

Correspondence: Edgardo S Santos
Florida Precision Oncology/A Division of 21st Century Oncology, Thoracic Oncology, Charles E. Schmidt College of Medicine, Florida Atlantic University, 3585 NE 207th Street, Suite C6-C7, Aventura, FL 33180, USA
Tel +1 561-334-2850
Fax +1 305-952-4866
Email edgardo.santos@21co.com

did patients who received an older drug, called erlotinib that also targets EGFR. Patients treated with afatinib also lived for longer overall than did patients who received erlotinib. Evidence from this clinical study and reports of individual patients suggest that patients with certain genetic mutations that are targeted by afatinib gain particular benefit from this drug. While afatinib does cause side effects, the most common of these are generally manageable by reducing the dose and treating the symptoms of the side effects. Further research is required to support the use of afatinib after immune checkpoint inhibitor treatment. However, it is possible that afatinib may be useful for some patients who are no longer gaining any benefit from combination treatment with chemotherapy and pembrolizumab (but are not suited to the other available therapies), and for patients who have received first-line immune checkpoint inhibitors followed by chemotherapy.

Introduction

Although the treatment of lung adenocarcinoma has progressed considerably in recent years, therapy for squamous cell carcinoma, the second most common type of non-small-cell lung cancer (NSCLC), lags well behind.¹ As in lung adenocarcinoma, driver mutations are common in squamous cell lung cancer; however, mutations have been found in a large number of genes, including *TP53*, *PIK3CA*, *CDKN2A*, *SOX2*, *CCND2*, *NOTCH1/2*, *MET*, and *FGFR1*.²⁻⁴ Squamous cell lung cancer has a particularly high tumor mutational burden (TMB), even in early-stage disease, with some cohorts displaying more than 200 exon mutations per tumor.⁵ In addition, tumor subclones may exhibit different combinations of mutations.⁶ Alterations in the tumor suppressor genes, *TP53* and *CDKN2A*, are particularly common in squamous cell lung cancer, with studies suggesting that more than half of patients with squamous cell lung cancer carry mutations in one (and potentially both) of these genes.^{2,4} However, as yet, no therapies targeting these mutations have been approved for squamous cell lung cancer. Less commonly, mutations are seen in the genes encoding members of the ErbB family of receptor tyrosine kinases, including the epidermal growth factor receptor (EGFR),⁴ for which targeted therapy is available. However, the nature of the mutations seen in squamous cell lung cancer differs considerably from lung adenocarcinoma, where two types of *EGFR* mutations (L858R and deletions in exon 19) predominate.⁴ As a result of the highly heterogeneous nature of squamous cell lung cancer and the wide range of mutations present, this tumor is particularly challenging to treat. In this article, we review current treatment options for squamous cell lung cancer, focusing on the role of the ErbB family inhibitor, afatinib, in this therapeutic landscape.

Literature Search Strategy

During the development of this review, we searched the published literature (English language only) for articles and presentations that reported clinical efficacy and safety of the second-generation EGFR tyrosine kinase inhibitor (TKI) afatinib in patients with advanced squamous cell carcinoma of the lung. Relevant publications were identified by searching the US National Library of Medicine (NLM) PubMed database, using combinations of the search terms [afatinib] AND [NSCLC] OR [squamous lung]. Reports of clinical trials and real-world evidence (case studies) were included. Other relevant publications were identified from citations in the key publications identified via NLM PubMed and from expert guidelines. Further information was obtained from the US prescribing information for afatinib.⁷

Current Treatment Approaches for Advanced/Metastatic Squamous Cell Lung Cancer

For patients testing positive for sensitizing *EGFR* mutations, anaplastic lymphoma kinase (*ALK*) gene rearrangements, ROS proto-oncogene 1 (*ROS1*) gene rearrangements, *B-RAF* proto-oncogene, serine/threonine kinase mutations (*BRAF*^{V600E}), or neurotrophic receptor tyrosine kinase (*NTRK*) gene fusions, therapy options are targeted to the specific genetic aberration, as follows: gefitinib, erlotinib, icotinib, afatinib, dacomitinib, or osimertinib for *EGFR* mutation-positive patients; crizotinib, ceritinib, alectinib, brigatinib, or lorlatinib for patients with *ALK* rearrangements; crizotinib, ceritinib, or entrectinib for patients with *ROS1* rearrangements; dabrafenib in combination with trametinib for patients with *BRAF*^{V600E} mutation; and larotrectinib or entrectinib for patients with *NTRK* gene fusions. However, as targetable genetic aberrations are not identified in most patients with advanced squamous cell lung cancer,^{4,8,9} systemic chemotherapy and more recently, immunotherapy, are the mainstay of treatment.

First-line therapy in patients without targetable mutations is generally determined by the level of programmed death ligand-1 (PD-L1) detected by immunohistochemical staining of tumor tissue. The use of immunotherapy in the first-line setting is supported by large Phase III studies demonstrating notably extended survival with regimens incorporating immune checkpoint inhibitors (Table 1). Of note, pembrolizumab is used in combination with carboplatin and either paclitaxel or nab-paclitaxel as first-line treatment for patients with metastatic squamous NSCLC, irrespective of PD-L1

Table I Summary of Key Clinical Data from Studies of Regimens Approved and Recommended in Key Guidelines for the Treatment of Advanced Squamous Cell Lung Cancer

| Study | Number of NSCLC Patients in Trial/Number with Lung SCC | Patient Population | Median PFS | Median OS | Survival HR vs Chemotherapy in Lung SCC Patients (95% CI) |
|--|--|---|---|---|---|
| First-line treatment | | | | | |
| Pembrolizumab vs platinum-based chemotherapy (KEYNOTE-024) ^{92,93} | 305/56 | PD-LI TPS ≥50% | 10.3 vs 6.0 months; $P<0.001$ | 30.0 vs 14.2 months; $P=NR$ | PFS 0.35 (0.17–0.71) |
| Pembrolizumab vs platinum-based chemotherapy (KEYNOTE-042) ¹¹ | 1274/492 | PD-LI TPS ≥1% | TPS ≥1%: 5.4 vs 6.5 months; $P=NR$ TPS 1–49%: NR | TPS ≥1%: 16.7 vs 12.1 months; $HR=0.81$; $P=0.0018$ TPS 1–49%: 13.4 vs 12.1 months; $HR=0.92$ | NR (SCC patients were not analyzed separately) |
| Pembrolizumab + platinum-based chemotherapy vs platinum-based chemotherapy (KEYNOTE-407) ⁹⁴ | 559/559 | Unselected (PD-LI TPS <1% and ≥1%) | 6.4 vs 4.8 months; $P<0.001$ | 15.9 vs 11.3 months; $HR=0.64$; $P<0.001$ | PFS 0.56 (0.45–0.70) |
| Nivolumab + ipilimumab vs platinum-based chemotherapy (CheckMate 227) ^{13,15} | PD-LI ≥1%: 1189/350 | Unselected (PD-LI <1% and ≥1%) | PD-LI ≥1%: 5.1 vs 5.6 months; $HR=0.82$ | PD-LI ≥1%: 17.1 vs 14.9 months; $P=0.007$ | PD-LI ≥1%: OS 0.69 (0.52–0.92) |
| Atezolizumab vs platinum-based chemotherapy (IMpower110) ¹⁶ | 554/167 | PD-LI ≥1% on TC or IC | TC3 or IC3 WT: 8.1 vs 5.0 months; $P=0.0070$ | TC3 or IC3 WT: 20.2 vs 13.1 months; $HR=0.59$; $P=0.0106$ | OS 0.56 (0.23–1.37) (for TC3 or IC3 WT) |
| Second-line treatment | | | | | |
| Nivolumab vs docetaxel (CHECKMATE 017) ²³ | 272/272 | Unselected patients with progressive disease after first-line platinum-based chemotherapy | 3.5 vs 2.8 months; $P<0.001$ | 9.2 vs 6.0 months; $P<0.001$ | PFS 0.62 (0.47–0.81) |
| Ramucirumab + docetaxel vs docetaxel (REVEL) ²² | 1253/328 | Unselected patients with progressive disease after first-line platinum-based chemotherapy | Overall population: 4.5 vs 3.0 months; $P<0.0001$ | Patients with SCC: 9.5 vs 8.2 months; $HR=0.88$ | NR (SCC patients not analyzed separately) |
| Atezolizumab vs docetaxel (OAK) ²⁴ | 850/222 | Unselected patients with progressive disease after ≤2 previous chemotherapy regimens | Overall population: 2.8 vs 4.0 months; $P=NS$ | Overall population: 13.8 vs 9.6 months; $HR=0.73$; $P=0.0003$ | OS 0.73 (0.54–0.98) |

(Continued)

Table 1 (Continued).

| Study | Number of NSCLC Patients in Trial/Number with Lung SCC | Patient Population | Median PFS | Median OS | Survival HR vs Chemotherapy in Lung SCC Patients (95% CI) |
|--|--|--|--|--|---|
| Pembrolizumab 2 mg/kg vs pembrolizumab 10 mg/kg vs docetaxel (KEYNOTE-010) ⁸⁴ | 1033/222 | Patients with PD-L1 TPS $\geq 1\%$ and progressive disease after platinum-based chemotherapy | Overall population: 3.9 vs 4.0 vs 4.0 months; $P=NS$ | Overall population: 10.4 vs 12.7 vs 8.5 months; $P<0.001$ for both pembrolizumab groups vs docetaxel | OS 0.74 (0.50–1.09); $P=NS$ |

Abbreviations: CI, confidence intervals; HR, hazard ratio; IC, tumor-infiltrating immune cells; NR, not reported; NS, not significant; NSCLC, non-small-cell lung carcinoma; OS, overall survival; PD-L1, programmed death-ligand 1; PFS, progression-free survival; SCC, squamous cell carcinoma; TC, tumor cells; TPS, tumor proportion score; WT, wild-type.

level.¹⁰ In addition, pembrolizumab monotherapy may be used as first-line treatment in patients with PD-L1 tumor proportion score (TPS) $\geq 1\%$,^{10,11} although monotherapy is generally preferred only when PD-L1 TPS is $\geq 50\%$.¹² Recently, the FDA approved two additional first-line therapies: nivolumab plus ipilimumab (PD-L1 $\geq 1\%$)^{13–15} and atezolizumab monotherapy in patients with high PD-L1 expression (PD-L1 stained $\geq 50\%$ of tumor cells [TC $\geq 50\%$] or PD-L1 stained tumor-infiltrating immune cells [IC] covering $\geq 10\%$ of the tumor area [IC $\geq 10\%$])^{16,17} (Table 1). For patients with contraindications to immunotherapy, such as autoimmune disease or previous solid organ transplant, combination cytotoxic chemotherapy is recommended.¹⁸

Options for second and subsequent treatment lines depend on the first-line therapy; agents with a different mode of action are generally recommended. For patients treated with chemotherapy in the first-line, options include nivolumab or atezolizumab for any level of PD-L1 expression,^{19,20} pembrolizumab if PD-L1 TPS is $\geq 1\%$,²¹ and the EGFR TKI, afatinib.^{7,12} For patients who received immunotherapy in the first line, docetaxel combined with ramucirumab has become an established second-line option.^{12,22–24} Further options include docetaxel or gemcitabine monotherapy, platinum-based chemotherapy (if not already received in combination with immunotherapy in the first line), and the ErbB family inhibitor, afatinib may also be considered suitable for further investigation in this setting.^{7,12}

The Role of the EGFR/ErbB Pathway in Squamous Cell Lung Cancer

The human EGFR family is composed of four members that belong to the ErbB protein lineage: EGFR (ErbB1/

human epidermal growth factor receptor [HER]1), ErbB2 (HER2/NEU), ErbB3 (HER3) and ErbB4 (HER4).²⁵ These receptor tyrosine kinases bind several growth factors, including EGF and transforming growth factor beta, forming a range of homo- and heterodimers that trigger downstream signaling pathways involved in cellular growth and proliferation. These pathways include the phosphatidylinositol 3-kinase/Akt (PKB) pathway, the Ras/Raf/MEK/ERK1/2 pathway, and the phospholipase C (PLC γ) pathway.

Increased expression or mutations in the ErbB family of receptor tyrosine kinases have been implicated in numerous malignancies, including lung, breast, stomach, colorectal, and pancreatic cancers, resulting in the development of a number of agents specifically targeting these receptors or their ligands (Figure 1).²⁵ Although *EGFR* mutations are relatively rare,⁴ studies suggest that EGFR is often overexpressed in squamous cell lung cancer.²⁶ In addition, *EGFR* gene copy number appears to be elevated in up to a quarter of patients with squamous cell lung cancer,^{4,27} and has been shown to correlate with EGFR expression.²⁶ Studies have shown that, in addition to EGFR, other members of the ErbB family (such as ErbB2 and ErbB3) may be over-expressed or mutated in around 20% of patients with squamous cell lung cancer.^{28–32} As a result, agents targeting EGFR have been investigated for possible use in squamous cell lung cancer (Table 2). The SQUIRE study in particular, suggested that EGFR was a valid therapeutic target in squamous cell lung cancer, with statistically significant increases in survival seen with first-line necitumumab plus platinum-based chemotherapy versus chemotherapy alone.³³ However, in the FLEX and BMS099 studies, which compared treatment outcomes with cetuximab monotherapy or cetuximab

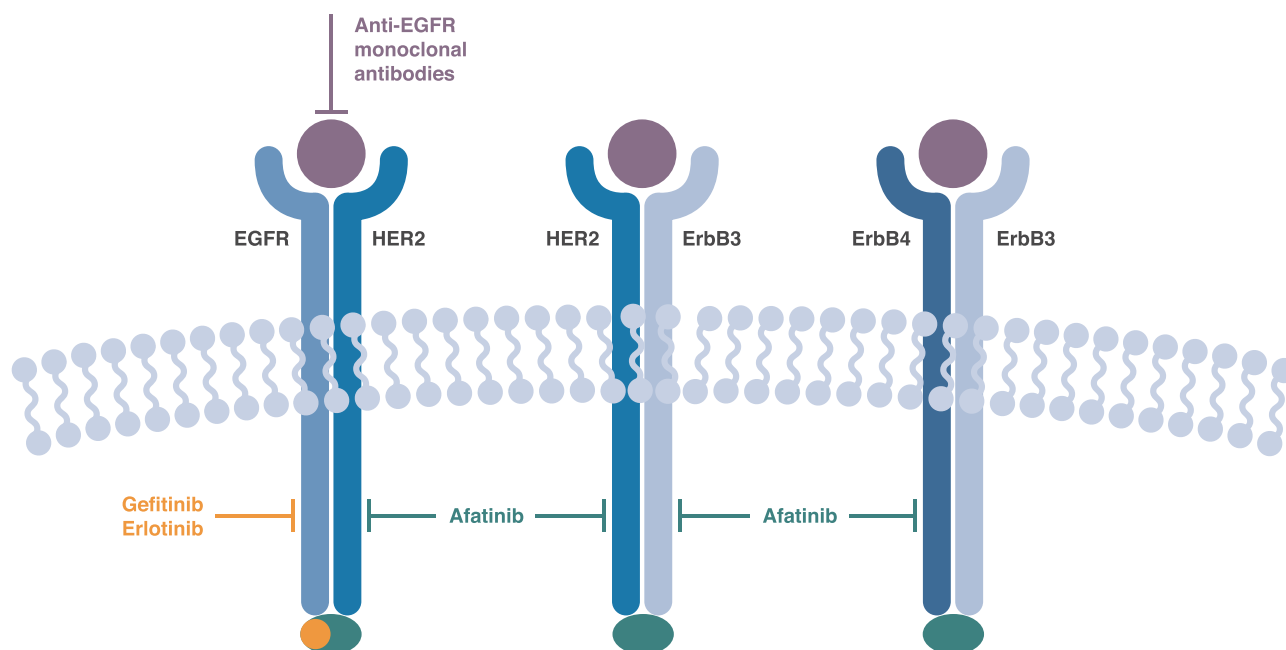


Figure 1 The ErbB family of receptor tyrosine kinases and the mechanism of action of targeted therapy. Data from these studies.^{33,95,96}
Abbreviations: EGFR, epidermal growth factor receptor; HER2, human epidermal growth factor receptor 2.

combined with platinum-based chemotherapy in patients with NSCLC, subset analyses of patients with squamous cell lung cancer indicated no significant difference in overall survival (OS) between the two treatment groups.^{34,35} Biomarker analyses from studies of anti-EGFR monoclonal antibodies suggested that patients with elevated EGFR expression or gene copy number derived greater benefit from anti-EGFR treatment than those with low or no EGFR expression or *EGFR* amplification,^{36–38} with results from the SQUIRE study suggesting little or no benefit for patients not expressing EGFR.³⁹

Based on results from a number of studies in NSCLC that included patients with squamous cell lung cancer,^{40–43} small molecule EGFR TKIs are not recommended for use as monotherapy or in combination with chemotherapy in the first-line treatment of unselected patients with squamous cell lung cancer. However, data from sub-analyses of studies investigating the second- or third-line use of EGFR TKI monotherapy in patients with NSCLC suggest a potential role for these agents in pre-treated patients. Significantly longer survival was seen in ever-smokers with squamous histology who received the reversible, first-generation EGFR-specific TKI, erlotinib, versus placebo, and a reduced risk of progression was observed in squamous cell lung cancer patients overall.^{44,45}

In the Phase III TAILOR study, erlotinib was compared with docetaxel as second-line treatment of patients with wild-type *EGFR* and advanced NSCLC.⁴⁶ Among the overall study

population, erlotinib was shown to be inferior to docetaxel, producing significantly shorter OS and progression-free survival (PFS). However, in the subset of patients with squamous cell lung carcinoma, OS was similar in the erlotinib and docetaxel groups (hazard ratio [HR]=0.90 [95% confidence interval {CI}=0.49–1.65]), suggesting that the differences in PFS and OS seen in the overall population were driven by inferior outcomes in the erlotinib arm among patients with adenocarcinoma (~69% of the study population). Although overall survival was similar between the two treatment arms in the squamous cell carcinoma patients, erlotinib appeared to be better tolerated than docetaxel across the entire population.

Another study (PROSE) comparing erlotinib and docetaxel for the second-line treatment of unselected patients with NSCLC used the commercially-available VeriStrat[®] serum protein test to classify patients according to whether they were likely to have a good or poor outcome after treatment with EGFR TKIs.⁴⁷ VeriStrat[®] uses matrix-assisted laser desorption ionization time-of-flight (MALDI-TOF) mass spectrometry to measure acute-phase reactant proteins in the blood and assign a “Good” (VS-G) or “Poor” (VS-P) classification.⁴⁸ PROSE was a prospective, randomized, multicenter, Phase III study that stratified patients according to a minimization algorithm by Eastern Cooperative Oncology Group (ECOG) performance status, smoking history, center, and masked pretreatment serum protein test classification.⁴⁷ The proteomic test classification

Table 2 Summary of Key Clinical Studies of Therapy Targeting EGFR in Patients with Advanced Squamous Cell Lung Carcinoma, Including the Investigation of Biomarkers Predicting Response to Therapy

| Study | Number of NSCLC Patients in Trial/ Number with Lung SCC | Patient Population | Median PFS | Median OS | Survival HR vs Chemotherapy in SCC Patients (95% CI) | Predictive Biomarkers |
|--|--|--|--|---|---|---|
| Necitumumab + gemcitabine-cisplatin vs gemcitabine-cisplatin (SQUIRE) ^{33,39} | 1093/1088 | Unselected patients with lung SCC | 5.7 vs 5.5 months; P=0.02 | 11.5 vs 9.9 months; P=0.01 | PFS 0.85 (0.74–0.98) OS (overall population) 0.84 (0.74–0.96) | Median ³⁷ OS significantly increased (>3.9 months) in necitumumab-treated patients with tumors expressing any level of the EGFR protein compared with patients not expressing EGFR |
| Cetuximab + cisplatin and vinorelbine vs cisplatin and vinorelbine (FLEX) ³⁴ | 1125/377 | Chemotherapy-naïve patients with NSCLC and IHC evidence of EGFR expression in at least one positively stained tumor cell | 4.8 vs 4.8 months; P=NS | 11.3 vs 10.1 months; P=0.04 | OS 0.80 (0.64–1.0) | NR |
| Cetuximab plus carboplatin-paclitaxel ± bevacizumab vs carboplatin-paclitaxel ± bevacizumab (SWOG S0819) ³⁸ | 1313/321 | Newly diagnosed or recurrent NSCLC | Overall population: 4.6 vs 4.5 months; P=0.83 | Overall population: 10.9 vs 9.2 months; P=0.22 | PFS 0.88 (0.70–1.11); P=0.29 OS 0.85 (0.67–1.07); P=0.17 | EGFR-FISH positivity was associated with significantly improved OS (11.8 vs 6.1 months; HR=0.58 [95% CI=0.39–0.86]; P=0.01) with cetuximab treatment vs chemotherapy |
| Erlotinib vs placebo (BR21) ⁴⁵ | 587/222 | Disease progression after first- or second-line chemotherapy | SCC patients: 2.3 vs 1.8 months; P=NR | 5.6 vs 3.6 months; P=NR | PFS 0.48 (0.35–0.67) OS 0.60 (0.44–0.82) | NR |
| Erlotinib vs docetaxel (TAILOR) ⁴⁶ | 219/54 | Wild-type EGFR and recurrence/progression after platinum-based chemotherapy | Overall population: 2.4 vs 2.9 months; P=0.02 | Overall population: 5.4 vs 8.2 months; P=0.05 | PFS 0.57 (0.32–1.03) OS 0.90 (0.49–1.65) | KRAS mutation was not associated with prognosis |
| Erlotinib vs pemetrexed or docetaxel (PROSE) ⁴⁷ | 263/47 | Advanced NSCLC and progression during or within 6 months after first-line platinum-based chemotherapy | NR | 7.7 vs 9.0 months; P=0.15 | PFS NR OS 1.08 (0.75–1.57) | Patients classified as VS-P had shorter OS on erlotinib than chemotherapy (HR 1.72 [95% CI 1.08–2.74]; P=0.022). No difference in OS between treatments among VS-G patients |

(Continued)

Table 2 (Continued).

| Study | Number of NSCLC Patients in Trial/ Number with Lung SCC | Patient Population | Median PFS | Median OS | Survival HR vs Chemotherapy in SCC Patients (95% CI) | Predictive Biomarkers |
|--|--|--|---|---|--|--|
| Afatinib vs erlotinib (LUX-Lung 8) ^{32,48,58} | 795/795* | Lung SCC and progression after platinum-based chemotherapy | 2.6 vs 1.9 months; <i>P</i> =0.01 | 7.9 vs 6.8 months; <i>P</i> =0.008 | PFS 0.81 (0.69–0.96) OS 0.81 (0.69–0.95) | In afatinib- but not erlotinib-treated patients, median PFS and OS were longer in those with <i>ErbB</i> mutations vs those without; <i>HER2</i> mutation may predict better outcomes with afatinib vs erlotinib; EGFR overexpression did not predict PFS or OS benefit with afatinib vs erlotinib |
| Cetuximab vs cetuximab plus taxane/carboplatin (BMS 099) ³⁵ | 676/132 | Chemotherapy-naïve patients with advanced NSCLC | 4.40 vs 4.24 months; <i>P</i> =0.236 | 9.69 vs 8.38 months; <i>P</i> =0.169 | PFS 0.70 (0.47–1.05) [†] OS 0.873 (0.599–1.275) | NR |

Notes: *32 patients had mixed histology; [†]Subset variable not prespecified in the statistical analysis plan.

Abbreviations: BMS, Bristol-Myers Squibb; CI, confidence interval; EGFR, epidermal growth factor receptor; FISH, fluorescence in situ hybridization; HR, hazard ratio; IHC, immunohistochemical; ITT, intent to treat; NR, not reported; NSCLC, non-small-cell lung cancer; OS, overall survival; PFS, progression-free survival; SCC, squamous cell carcinoma; VS-G, Veristrat®-good; VS-P, Veristrat®-poor.

was masked for patients, and investigators who gave treatments, and treatment allocation was masked for investigators who generated the proteomic classification. This study showed no differences in OS between treatment groups in patients classified as VS-G (adjusted HR=1.06 [95% CI=0.77–1.46], *P*=0.714). However, OS was longer with docetaxel than erlotinib in patients classified as VS-P (HR=1.72 [95% CI=1.08–2.74], *P*=0.022), indicating that chemotherapy is a better choice in these patients.⁴⁷ A more recent randomized, Phase III study, conducted in patients with advanced squamous cell lung carcinoma supported these findings, with comparable PFS and OS with erlotinib and docetaxel seen in VS-G patients.⁴⁹ In this study, however, no difference in survival between the treatment arms was seen in patients classified as VS-P. Across the entire study population and within each treatment arm, survival was significantly longer in VS-G patients compared with VS-P patients (median OS, 8.2 versus 5.2 months).

Clinical Experience with Afatinib in Patients with Squamous Cell Lung Cancer

Afatinib is a second-generation, irreversible ErbB family blocker that inhibits signaling from all ErbB hetero- and homodimers,⁵⁰ conferring a wider inhibitory profile than first-generation, reversible EGFR-specific agents such as erlotinib and gefitinib.⁵¹ Afatinib has shown considerable efficacy in patients with *EGFR* mutation-positive NSCLC, and is approved as first-line treatment in this indication.⁷ In patients with NSCLC and sensitizing mutations in the *EGFR* gene, afatinib has been shown to significantly prolong median PFS compared with platinum-based chemotherapy,^{52,53} and a significant OS improvement has been observed with afatinib in patients with tumors harboring the exon 19 deletion (Del19) *EGFR* mutation.⁵⁴ Further, the randomized Phase IIb LUX-Lung 7 trial demonstrated that afatinib was associated with

significantly longer PFS than gefitinib.⁵⁵ Afatinib is also the only EGFR TKI with United States Food and Drug Administration (US FDA) approval for uncommon *EGFR* mutations based on PFS and response rate.⁷

Although afatinib is not recommended as first-line therapy for unselected patients with squamous cell lung cancer and wild-type *EGFR*,^{12,18} it has demonstrated efficacy as second-line therapy in patients with metastatic squamous cell lung cancer following progression on platinum-based chemotherapy, and is approved by the US FDA for use as monotherapy in this patient population.⁷ However, despite the US FDA approval status, the inclusion of afatinib as a second-line treatment option for patients with squamous cell lung cancer varies across treatment guidelines, reflective of the changing treatment landscape in recent years. For example, afatinib is no longer included as a second-line treatment option for patients with metastatic squamous cell non-small-cell lung cancer in the NCCN Clinical Practice Guidelines In Oncology (NCCN Guidelines®) Version 6.2020.⁵⁶ Conversely, the latest ESMO Clinical Practice guidelines (September 2019) state that afatinib “could be a therapeutic option” for patients with advanced squamous cell lung cancer with unknown or wild-type *EGFR* status progressing on/after chemotherapy, who are unfit for further chemotherapy or immunotherapy.⁵⁷

LUX-Lung 8

The approval of afatinib for use in patients who have progressed on platinum-based chemotherapy was based on results from the open-label, Phase III LUX-Lung 8 study, which compared the second-line use of afatinib (n=398) with erlotinib (n=397) in patients with advanced squamous cell lung cancer.⁵⁸ Median PFS was longer with afatinib compared with erlotinib (2.4 months [95% CI=1.9–2.9] versus 1.9 months [95% CI=1.9–2.2]; HR=0.82 [95% CI=0.68–1.00], $P=0.0427$), as was OS (median 7.9 months [95% CI=7.2–8.7] versus 6.8 months [95% CI=5.9–7.8]; HR=0.81 [95% CI=0.69–0.95], $P=0.0077$; Figure 2). Although the proportion of patients with an objective response did not differ significantly between the treatment groups (6% versus 3%, $P=0.055$), the disease control rate was significantly higher in the afatinib group (51% versus 40%, $P=0.002$).

Overall adverse event profiles were similar between the two treatment arms, with 57% of patients in each group experiencing a grade ≥ 3 adverse event. However, afatinib was associated with higher incidence of grade ≥ 3 treatment-related diarrhea (10% versus 3%) and grade 3

stomatitis (4% versus 0%) than erlotinib (Table 3). Overall, 27% of afatinib-treated patients and 14% of erlotinib-treated patients underwent dose reduction due to adverse events, and 20% and 17% of patients, respectively, discontinued treatment because of adverse events.

Data on patient-reported outcomes from LUX-Lung 8 suggest that the higher rate of adverse events with afatinib did not impact on symptom scores or quality of life, as assessed by the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire C30 and its lung cancer-specific module, the QLQ-LC13.⁵⁹ Moreover, significantly higher proportions of patients in the afatinib group than in the erlotinib group reported improved scores on the global health status/quality of life (36% versus 28%, $P=0.041$), cough (43% versus 35%, $P=0.029$), and “dyspnea walked” scales (35% versus 27%, $P=0.022$); differences in the frequency of improvements in other scales, including pain (40% versus 39%) and dyspnea (51% versus 44%), were not significant. Time to deterioration of dyspnea was significantly longer in afatinib-treated patients (median 2.6 versus 1.9 months, $P=0.008$).

Initial biomarker analyses using archival tissue from a subset of patients in LUX-Lung 8 indicated that the observed responses to afatinib were unlikely to be related to *EGFR* mutation or amplification.⁵⁸ Additional analysis, conducted by Foundation Medicine (Cambridge, MA, USA) using next-generation sequencing, of a separate cohort of patients from LUX-Lung 8 that was enriched for patients with PFS >2 months indicated that these patients harbored a range of mutations, including *TP53* (87% of patients), *LRP1B* (39%), *KMT2D* (33%), *CDKN2A* (29%) and *FAT3* (26%).³² Among the 245 patients undergoing molecular analysis, 22% had tumors with at least one *ErbB* family mutation, including a small proportion with mutations in more than one *ErbB* gene, and 7% of patients had at least one *EGFR* mutation. In the afatinib arm, both PFS (median 4.9 versus 3.0 months, $P=0.06$) and OS (median 10.6 versus 8.1 months, $P=0.21$) were numerically longer in patients who had *ErbB* mutation-positive tumors (n=25) compared to those without *ErbB* mutations (n=107). In contrast, PFS and OS were similar in patients with (n=28) and without (n=85) *ErbB* mutations in the erlotinib arm (median PFS: 2.7 versus 2.5 months, $P=0.29$; median OS: 7.2 versus 6.4 months, $P=0.46$). Interestingly, the enhanced benefit of afatinib over erlotinib in patients with *ErbB* mutation-positive tumors appeared to be driven by mutations in *HER3*,

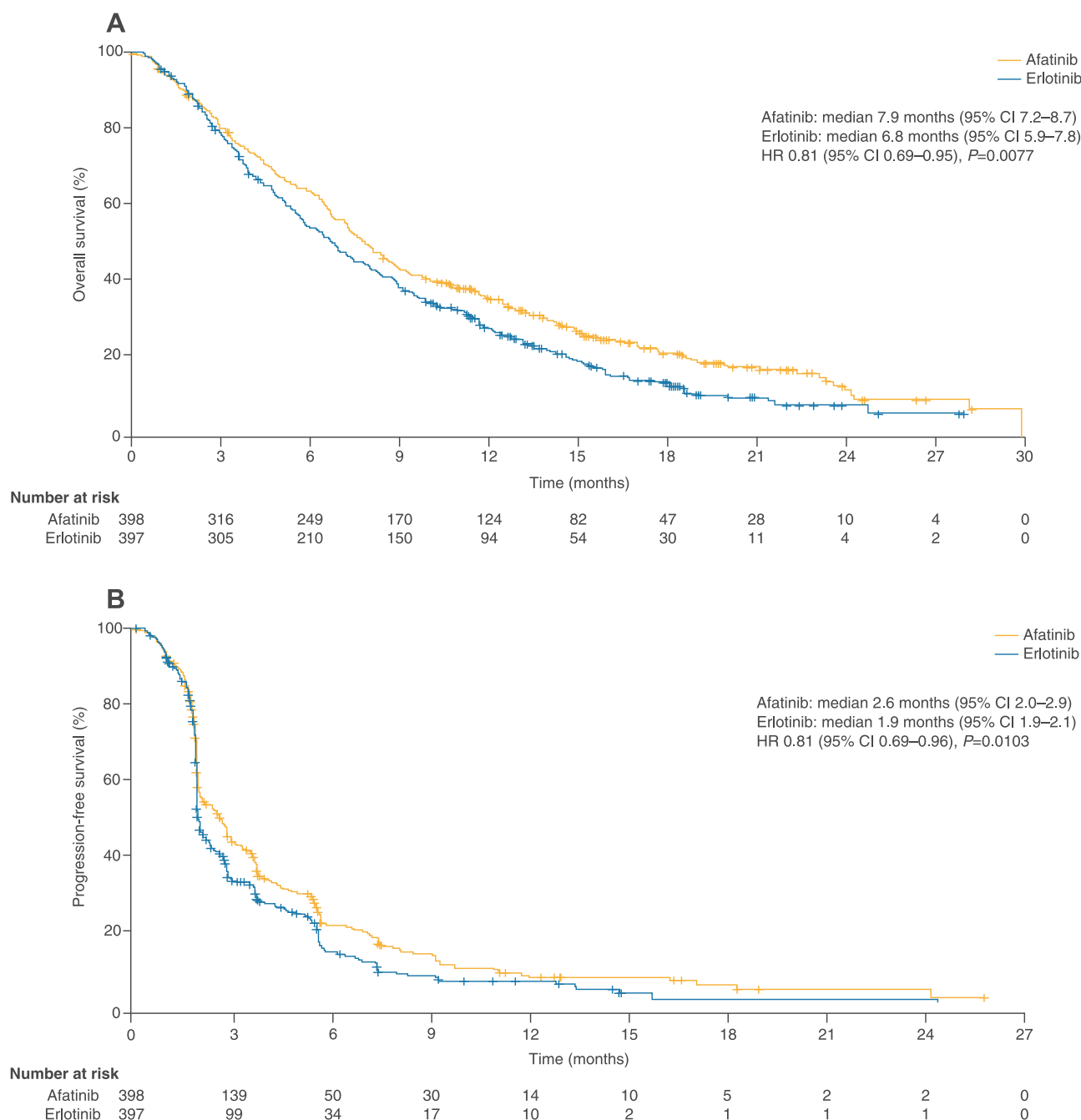


Figure 2 Progression-free (A) and overall (B) survival in the overall study population of LUX-Lung 8. – Reprinted from *The Lancet Oncology*, Vol 16, Soria JC, Felip E, Cobo M, et al. Afatinib versus erlotinib as second-line treatment of patients with advanced squamous cell carcinoma of the lung (LUX-Lung 8): an open-label randomised controlled phase 3 trial, pp. 897–907, Copyright (2015), with permission from Elsevier.⁵⁸

Abbreviations: CI, confidence interval; HR, hazard ratio.

HER4, and, in particular, *HER2*, rather than *EGFR*. Among 12 patients with *HER2*-positive tumors, PFS (HR=0.06 [95% CI=0.01–0.59], $P=0.02$) and OS (HR=0.06 [95% CI=0.01–0.57], $P=0.02$) significantly favored treatment with afatinib over erlotinib. In contrast, *EGFR* overexpression did not predict PFS or OS benefit with afatinib over erlotinib.

Another retrospective analysis of LUX-Lung 8 was conducted using the VeriStrat[®] serum protein test.⁴⁸ Among 412 (afatinib, $n=207$; erlotinib, $n=205$) patients classified as VS-G, OS was significantly longer with afatinib versus erlotinib (median 11.5 versus 8.9 months; HR=0.79 [95% CI=0.63–0.98], P not reported). In the VS-P group (afatinib, $n=129$; erlotinib, $n=134$), there

Table 3 Most Common Treatment-Related Adverse Events Seen in LUX-Lung 8*.

| | Afatinib (n=392) | | | | Erlotinib (n=395) | | | |
|---------------------------|------------------|----------|----------|---------|-------------------|----------|----------|---------|
| | Grade 1 | Grade 2 | Grade 3 | Grade 4 | Grade 1 | Grade 2 | Grade 3 | Grade 4 |
| Diarrhea | 165 (42%) | 68 (17%) | 39 (10%) | 2 (<1%) | 94 (24%) | 28 (7%) | 9 (2%) | 1 (<1%) |
| Rash or acne [†] | 157 (40%) | 83 (21%) | 23 (6%) | 0 (0%) | 142 (36%) | 83 (21%) | 41 (10%) | 0 (0%) |
| Stomatitis [†] | 65 (17%) | 32 (8%) | 16 (4%) | 0 (0%) | 21 (5%) | 13 (3%) | 0 (0%) | 0 (0%) |
| Fatigue [†] | 33 (8%) | 20 (5%) | 6 (2%) | 0 (0%) | 24 (6%) | 17 (4%) | 7 (2%) | 0 (0%) |
| Nausea | 35 (9%) | 13 (3%) | 4 (1%) | 0 (0%) | 20 (5%) | 5 (1%) | 3 (<1%) | 0 (0%) |
| Decreased appetite | 31 (8%) | 16 (4%) | 3 (<1%) | 0 (0%) | 24 (6%) | 15 (4%) | 2 (<1%) | 0 (0%) |
| Paronychia [†] | 28 (7%) | 11 (3%) | 2 (<1%) | 0 (0%) | 9 (2%) | 7 (2%) | 1 (<1%) | 0 (0%) |
| Dry skin | 28 (7%) | 4 (1%) | 2 (<1%) | 0 (0%) | 34 (9%) | 7 (2%) | 0 (0%) | 0 (0%) |
| Pruritus | 22 (6%) | 9 (2%) | 1 (<1%) | 0 (0%) | 37 (9%) | 10 (3%) | 0 (0%) | 0 (0%) |
| Vomiting | 20 (5%) | 8 (2%) | 3 (<1%) | 0 (0%) | 7 (2%) | 4 (1%) | 2 (<1%) | 0 (0%) |
| Dehydration | 2 (<1%) | 5 (1%) | 3 (<1%) | 4 (1%) | 0 (0%) | 0 (0%) | 3 (<1%) | 0 (0%) |

Notes: *Includes grade 1–2 adverse events that occurred in >10% of patients, or grade 3–5 adverse events that occurred in >1% patients within any treatment group.

[†]Grouped term. Reprinted from *The Lancet Oncology*, Vol 16, Soria JC, Felip E, Cobo M, et al. Afatinib versus erlotinib as second-line treatment of patients with advanced squamous cell carcinoma of the lung (LUX-Lung 8): an open-label randomised controlled phase 3 trial, pp. 897–907, Copyright (2015), with permission from Elsevier.⁵⁸

was no significant difference in OS between afatinib and erlotinib (median 4.7 versus 4.8 months; HR=0.90 [95% CI=0.70–1.16], *P* not reported). Multivariate analysis showed that VeriStrat[®] classification was an independent predictor of OS in afatinib-treated patients, regardless of ECOG performance status or best response to first-line therapy. Together, these findings suggest that certain groups of patients with squamous cell lung cancer, such as those with *HER2* mutations and those classified as VS-G, may derive particular benefit from afatinib.

It is important to note that the LUX-Lung 8 study was performed when the first-line standard of care for unselected patients with squamous cell lung cancer was chemotherapy. The treatment landscape has markedly expanded since LUX-Lung 8 was conducted; most notably, immune checkpoint inhibitors with or without chemotherapy are now available as first- and second-line treatment options, and erlotinib would no longer be considered a relevant comparator for second-line treatment in a prospective clinical trial. Docetaxel in combination with ramucirumab is now an established second-line treatment; however, at present there are no prospective, clinical data comparing afatinib with docetaxel alone or in combination with ramucirumab.

Safety of Afatinib and Use of the Tolerability-Guided Dose Modification Protocol

Afatinib has an established, predictable, and manageable safety profile that is consistent with its mode of action.^{52,53}

No new safety signals were observed in patients with squamous cell lung cancer in LUX-Lung 8, with diarrhea (all grades/grade ≥ 3 : 70/10%), rash/acne (67/6%), and stomatitis (29/4%) being the most common adverse events with afatinib (Table 3).⁵⁸

Although afatinib can be associated with some severe treatment-related adverse events, following the established tolerability-guided dose modification protocol can help mitigate these reactions and allow patients to remain on treatment for as long as possible.⁵³ According to this protocol,⁷ afatinib should be withheld for: any adverse reactions of grade ≥ 3 ; diarrhea of grade 2 persisting for ≥ 2 consecutive days while taking anti-diarrheal medication; cutaneous reactions of grade 2 that last >7 days or are intolerable. Treatment should be resumed at a reduced dose when the adverse reaction has fully resolved, improved to grade 1, or returned to baseline. Dosing should be reduced by 10 mg decrements, to a minimum of 20 mg/day. Results from several studies in patients with

EGFR mutation-positive NSCLC have shown that dose reductions reduce the incidence and severity of treatment-related adverse events, without reducing the efficacy of afatinib.^{60–62}

Although dose reductions in LUX-Lung 8 occurred more frequently in patients treated with afatinib (27%) than with erlotinib (14%),⁵⁸ this may have been due to the availability of multiple dose formulations of afatinib and the clear dose modification guidelines in the accompanying prescribing information.⁷ The implementation of these guidelines may underlie the finding that similar proportions of patients in the afatinib and erlotinib groups discontinued treatment due to adverse events (20% versus 17%), despite the fact that more patients in the afatinib group than the erlotinib group experienced grade ≥ 3 treatment-related adverse events (27% versus 17%) and/or required dose reductions.⁵⁸

As noted previously, because the LUX-Lung 8 study was conducted before immunotherapy became the mainstay for the first-line treatment of advanced squamous cell lung cancer, there are no clinical trial data investigating the effect of prior immunotherapy on safety outcomes with afatinib.

Evidence from Individual Patient Cases

No additional clinical trial data on the use of afatinib as second-line treatment of advanced squamous cell lung cancer are available. As such, reports from the “real-world” clinical setting provide important information on treatment outcomes with second-line afatinib following chemotherapy or immunotherapy. In these settings, a number of patient case examples support the use of afatinib in patients with particular clinical characteristics, including *ErbB* family mutations. For example, afatinib given after chemotherapy, antiangiogenesis therapy, and icotinib successfully stabilized *EGFR* and *HER2* mutation-positive squamous cell lung cancer in an elderly Chinese patient for at least 8 months, with no treatment-related adverse events.⁶³ Further details have also been published of a patient enrolled in LUX-Lung 8, with multiple genetic aberrations, including *EGFR* copy number amplification and mutations in *ErbB4*, *ALK*, *RET* and *BRCA*. This patient experienced prolonged PFS (14.7 months) and OS (17.7 months) with afatinib;⁶⁴ of note, final analysis of LUX-Lung 8 has since identified 21 patients who remained on afatinib treatment for at least 12 months.⁶⁵

Afatinib has also provided clinical benefit to patients without detectable genetic anomalies, including a patient who had received chemotherapy, radiotherapy, and

radiosurgery, and subsequently developed hemoptysis following treatment with nivolumab.⁶⁶ This patient, who had no detectable *EGFR* or *ALK* aberrations, experienced symptomatic relief from dysphonia shortly after commencing afatinib, with no obvious adverse effects. Afatinib was given to another elderly patient who had experienced disease progression and left lung atelectasis following first-line nab-paclitaxel, resulting in resolution of the atelectasis and shrinkage of the central tumor mass, with no adverse effects.⁶⁷

Where Does Afatinib Fit in the Squamous Cell Lung Cancer Treatment Paradigm?

Personalized treatment based on validated predictive biomarkers as well as individual characteristics is nowadays the optimal approach for the treatment of NSCLC. Unfortunately, unlike for patients with adenocarcinoma NSCLC, to date, no predictive genomic biomarkers have been identified for NSCLC of squamous cell histology. Hence, cytotoxic chemotherapy and immune checkpoint inhibitors are the established “gold standard” for the first-line treatment of most patients with advanced squamous cell lung cancer,^{12,18} with the choice of regimen dependent on many factors, including the patient’s age, performance status, and PD-L1 TPS. Following progression on first-line therapy, molecular and physical characteristics may preclude use of further chemotherapy, and alternative treatments will be required for some patients. Alternative options will also be required to treat patients for whom immunotherapy is contraindicated, such as those with autoimmune disease.

For certain patients who are not candidates for cytotoxic chemotherapy or immunotherapy and have a good performance status, afatinib may represent a convenient second- or third-line treatment option. The challenge for clinicians is identifying these patients in routine clinical practice, and further research into predictive biomarkers that can be easily applied in the clinic is clearly needed. The Veristrat[®] proteomic test has been validated and is covered by payors in the USA, including Medicare and Medicaid; the turnaround time is approximately 72 hours. As discussed above, having a patient with VS-G classification will give a level of comfort to physicians to treat the patient with an *EGFR* TKI over systemic chemotherapy. Moreover, evidence from patient case studies suggests that some unselected patients have experienced long-term benefit from afatinib, with minimal

toxicity, suggesting that a trial may be worthwhile in patients who are not candidates for other therapies.

Until more data are available, afatinib could be considered a potential second- or third-line treatment option for some patients who are not eligible for other more established therapies. For example, as a second-line option for patients who have progressed on combined chemo-immunotherapy and who are ineligible for docetaxel plus ramucirumab, and as a third-line option in patients who have received first-line immunotherapy and second-line chemotherapy (e.g., docetaxel, gemcitabine or platinum-based chemotherapy) or chemotherapy and antiangiogenesis therapy (e.g. docetaxel plus ramucirumab). Due to the currently limited range of second- and third-line treatment options, investigating an agent with an entirely new mechanism of action is warranted, particularly in patients with physical or molecular characteristics that preclude the use of chemotherapy. Also, if available, molecular analysis to identify *ErbB* family mutations could help to further identify patients who may be likely to derive the most benefit from afatinib, in addition to Veristrat[®] profiling as previously discussed. Importantly however, further data are required to establish the optimal place for afatinib in the squamous cell lung cancer treatment landscape, specifically among the first- and second-line treatment options that have emerged in recent years.

Afatinib may also be of value for patients who find that intravenous administration of chemotherapy and immunotherapy is logistically problematic (for example, if there is a preference or need to restrict travel to the clinic for drug infusion), or substantially impacts on their quality of life. Studies suggest that oral therapies are generally preferred by patients,^{68,69} and may improve quality of life since oral drug administration is more convenient and flexible.^{68,70} Further, oral treatment eliminates the risks and discomfort associated with intravenous administration, such as phlebitis, pain, infection, bleeding, infusion reactions, and vascular damage, and frees up valuable healthcare resources.^{11,69-71}

No cost-effectiveness data on the use of afatinib as second-line treatment of advanced squamous cell lung cancer in the US are currently available, and further data are required in this respect. However, analyses of the LUX-Lung 8 study, undertaken from the perspective of patients treated in France and China, suggest that afatinib may be cost-effective in those countries.^{72,73} The French analysis calculated a 97% probability of afatinib being cost-effective, assuming a willingness-to-pay threshold of EUR70,000 per quality-adjusted life year gained.⁷²

The Future of Squamous Cell Lung Cancer Therapy

A number of trials are ongoing or recently completed that may offer further options for patients with squamous cell lung cancer. Results from the Phase III CHECKMATE-227 study enrolling chemotherapy-naïve patients with stage IV NSCLC have led to nivolumab plus the anti-cytotoxic T-lymphocyte-antigen (CTLA) 4 monoclonal antibody, ipilimumab, being recently approved by the FDA as a first-line treatment option for patients with PD-L1 $\geq 1\%$. In the most recent analysis, nivolumab plus ipilimumab was shown to prolong median OS relative to platinum-based chemotherapy in patients with PD-L1 expression $\geq 1\%$ (17.1 versus 14.9 months, $P=0.007$) and in patients with PD-L1 $<1\%$ (17.2 versus 12.2 months, P not reported).¹³⁻¹⁵ Nivolumab in combination with chemotherapy, however, did not prolong survival relative to chemotherapy alone.⁷⁴

In the second-line setting in patients with squamous cell lung carcinoma, the ipilimumab plus nivolumab combination does not appear to offer any advantages over nivolumab alone. Results from a non-biomarker-matched substudy of the Phase III Lung-MAP umbrella trial showed that adding ipilimumab to nivolumab in previously treated but immunotherapy-naïve patients with advanced squamous cell lung carcinoma with any PD-L1 level did not enhance survival.⁷⁵ Further findings from the biomarker-driven Lung-MAP study, which is currently investigating a number of different targeted therapies in NSCLC, including durvalumab plus tremelimumab and rucaparib, may further advance the use of personalized therapy in squamous cell lung carcinoma.^{12,76}

Results from the Phase III IMpower110 study, enrolling chemotherapy-naïve patients with stage IV NSCLC, has led to recent FDA approval of atezolizumab monotherapy as a first-line treatment option for patients with high PD-L1 expression. Atezolizumab monotherapy was shown to significantly prolong median OS relative to platinum-based chemotherapy in patients with high PD-L1 expression (20.2 versus 13.1 months, $P=0.0106$). Primary analysis of the Phase III IMpower131 study suggested that the addition of atezolizumab to platinum-based chemotherapy in the first-line treatment of advanced squamous cell lung cancer prolonged survival.⁷⁷ Median PFS with atezolizumab plus chemotherapy was 6.3 months compared with 5.6 months in patients receiving chemotherapy alone (HR=0.71 [95% CI=0.60–0.85], $P=0.0001$).⁷⁷

However, final OS analysis suggested that the addition of atezolizumab only prolongs OS in patients with high PD-L1 levels, with median OS of 14.2 months in patients receiving chemotherapy plus atezolizumab compared with 13.5 months (HR=0.88 [95% CI=0.73–1.05]; $P=0.158$) for chemotherapy alone in the intention to treat populations, and 23.4 versus 10.2 months (HR=0.48 [95% CI=0.29–0.81]; P not formally calculated) in the PD-L1-high population.⁷⁷ No differences in median OS were seen between the treatment arms in the overall PD-L1-positive population (14.8 versus 15.0 months), or in PD-L1-negative patients (median 14.0 versus 12.5 months).⁷⁷

Early-phase studies are also exploring various combinations of approved and investigational agents, including pembrolizumab plus ramucirumab,⁷⁸ and novel agents such as anlotinib⁷⁹ and camrelizumab.⁸⁰

It has been suggested that radiotherapy in addition to chemotherapy plus immune checkpoint inhibitors, the current first-line standard of care for patients with advanced NSCLC, may further improve outcomes, but this strategy is yet to be tested in clinical trials.⁸¹

Compared with afatinib monotherapy, afatinib combination therapy with other agents may yield better efficacy results in general *EGFR* wild-type populations. The Phase II, single-arm LUX-Lung IO/KEYNOTE-497 is investigating the efficacy of afatinib plus pembrolizumab in unselected patients with locally advanced/metastatic squamous cell lung carcinoma that has progressed during or after first-line platinum-based chemotherapy.⁸² Enrollment for this study has closed, but no results are available as yet.

Conclusions

Agents such as chemotherapy and immune checkpoint inhibitors appear to be the most efficacious therapies across a broad range of patients with squamous cell lung carcinoma when used early in the disease course. Further data are required to establish the optimal place for afatinib within the squamous cell lung cancer treatment landscape. However, until further data are available afatinib may be considered an option for some patients who have progressed on previous therapies but are not eligible for existing, more-established therapies.

Afatinib may be a particularly good second- or third-line option in certain problematic clinical scenarios. When immunotherapy is used alone or in combination with chemotherapy as first-line treatment, the findings from CheckMate 017 (nivolumab versus docetaxel in unselected patients with

progressive disease after first-line platinum-based chemotherapy)²³ and OAK (atezolizumab versus docetaxel in unselected patients with progressive disease after one or two previous chemotherapy regimens)²⁴ studies cannot be applied. In addition, if the patient was initially treated with pembrolizumab, Keynote-001 (pembrolizumab in patients with treatment failure after prior systemic therapy⁸³) and Keynote-010 (pembrolizumab versus docetaxel in patients with PD-L1 TPS $\geq 1\%$ and progressive disease after platinum-containing chemotherapy⁸⁴) are also not applicable.

These limitations leave only four options as second- or subsequent-line treatment for many patients. These are docetaxel plus ramucirumab, afatinib, gemcitabine as a single agent or as one of several available platinum-doublet chemotherapy options, and participation in a clinical trial. The REVEL trial showed that the combination of docetaxel and ramucirumab was superior to docetaxel alone,²² suggesting that docetaxel monotherapy is no longer appropriate unless the patient cannot receive ramucirumab. As ramucirumab was not studied in patients with centrally-located tumors or cavitation, docetaxel in combination with ramucirumab may not be appropriate in such scenarios.^{22,85}

The second option, oral afatinib monotherapy, has been shown to confer an OS benefit over erlotinib in patients with squamous cell lung cancer.⁵⁸ Although erlotinib is no longer approved in this indication, and direct comparisons cannot be made with other agents, the OS seen in patients who progressed after platinum-based chemotherapy with afatinib (7.9 months) is comparable to that seen with docetaxel (8.2 months) in the REVEL study in the second-line setting.²² Notably, both the REVEL and LUX-Lung 8 studies were conducted before the immunotherapy era. Recent data among patients with *EGFR* mutation-positive NSCLC suggesting that the use of afatinib following anti-PD-(L)1 therapy is not associated with severe immune-related adverse events⁸⁶ are reassuring, and support further investigation of afatinib in patients who have previously received immune checkpoint inhibitors.

The third option is gemcitabine therapy; however, the data supporting its use as a single agent in the second-line setting come primarily from Phase II studies.^{87–89} Certainly, the use of platinum-based doublets incorporating gemcitabine in chemotherapy-naïve NSCLC patients is well established, with comparable efficacy to other platinum-based combinations.⁹⁰ Gemcitabine monotherapy may also be useful in the maintenance setting. In a Phase III study, gemcitabine or erlotinib maintenance was compared with observation alone in patients whose disease was controlled

after cisplatin-gemcitabine induction chemotherapy.⁹¹ This study demonstrated that maintenance therapy with erlotinib (switch) or gemcitabine (continuation) significantly delayed disease progression after cisplatin-gemcitabine induction.

In summary, afatinib monotherapy may be a suitable therapeutic option for some patients with squamous cell lung cancer in the second- or third-line setting, but further assessment of the optimal place of afatinib within the current treatment landscape is required. Further, biomarker analyses and a small number of case studies suggest that certain groups of patients, such as those harboring mutations in the *ErbB* family of receptor tyrosine kinases, may derive particular benefit from afatinib. Further studies should help to determine whether efficacy can be improved by the addition of other agents such as pembrolizumab.

Abbreviations

ALK, anaplastic lymphoma kinase; CI, confidence interval; Del19, deletion in exon 19 of the *EGFR* gene; ECOG, Eastern Cooperative Oncology Group; EGFR, epidermal growth factor receptor; FDA, Food and Drug Administration; HER2, human epidermal growth factor receptor; HR, hazard ratio; NLM, National Library of Medicine; NSCLC, non-small-cell lung cancer; NTRK, neurotrophic receptor tyrosine kinase; OS, overall survival; PD-L1, programmed death-ligand 1; PFS, progression-free survival; SCC, squamous cell carcinoma; TKI, tyrosine kinase inhibitor; TMB, tumor mutational burden; TPS, tumor proportion score; US, United States.

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