SCIENTIFIC THOUGHT
Website: https://scithought.com
Email:editor@scithought.com
ISSN 3080-4221 (Print)
3080-423X (Online)

Clinical Outcomes of Immunotherapy in Stage IV Non-Small Cell Lung Cancer Patients

Hassan Yar Mahsood [1*], **Sajjad Mehdi**[2]

[1]Gomal Medical College, MTI, Dera Ismail Khan 29050 Khyber Pakhtunkhwa, Pakistan

[2]King Edward Medical College, Lahore, Punjab Pakistan (sajjadmedical789@outlook.com)

*Corresponding author E-mail: hassanyarmahsood@gmail.com

Article History

Received:
January 05, 2025

Revised:
February 18, 2025

Accepted:
March 23, 2025

Available Online:
June 30, 2025

Abstract

Immunotherapy has revolutionized the treatment landscape for metastatic non-small cell lung cancer (NSCLC), yet therapeutic resistance remains a significant barrier. This study evaluated clinical, molecular, and imaging data from patients treated with immune checkpoint inhibitors (ICIs), including anti-PD-1, anti-PD-L1, and combination regimens. Among the treatment groups, combination immunotherapy demonstrated the highest objective response rate (ORR) at 55% and the longest median overall survival (OS) of 21.3 months. Patients with high PD-L1 expression and elevated tumor mutational burden (TMB) showed superior clinical responses, while resistance was commonly associated with biomarkers such as STK11 loss, T-cell exclusion, and low PD-L1 expression. Immune-related adverse events (irAEs), such as pneumonitis and colitis, occurred in up to 12% of patients, but were generally manageable. Imaging modalities like PET/CT and molecular fluorescence were effective in differentiating pseudo-progression from true progression, improving treatment monitoring. A comprehensive analysis of resistance profiles revealed that 30–50% of patients experienced limited benefit from ICIs due to intrinsic or acquired resistance mechanisms. The study emphasizes the need for biomarker-guided therapy and suggests that integration of immunotherapy with chemotherapy or targeted agents may enhance outcomes. Furthermore, emerging next-generation immunotherapeutics and advanced imaging hold promise for more personalized, adaptive treatment strategies. These findings contribute to the evolving understanding of immunotherapy in NSCLC and support a precision medicine framework to optimize patient management and long-term survival.

Keywords: Immunotherapy, Non-Small Cell Lung Cancer, Pd-L1, Tumor Mutational Burden, Resistance Biomarkers, Survival Outcomes.

INTRODUCTION

Immunotherapy is now a standard treatment in metastatic non-small cell lung cancer and gives hope to some patients (Russano et al., 2023). Cytotoxic T-lymphocyte antigen 4, programmed cell death-ligand 1 and antibodies directed at programmed cell death-1 have all been found to be very effective when used as immune checkpoint inhibitors (Sarantis et al., 2020). These medicines release the anti-cancer activity of the patient's immune system and may continue to manage the disease for a long time (Stanley et al., 2023). Because of its high rate among many people worldwide and death toll, lung cancer is typically squamous cell carcinoma or adenocarcinoma which fall under the non-small cell lung cancer group and are present in 80% of all cases (Z Zhou & Yang, 2023). Now that immunotherapy can be given alone or together, it is used as an initial or follow-up approach for non-small cell lung cancer (Kong et al., 2021) and is greatly changing how cancer treatments are delivered. But even so, between one-third and half of patients do not keep improving after using immunotherapy, meaning we must further study why it does not work for them and how to predict those patients.

Thanks to immune checkpoint inhibitors, the outlook for advanced non-small cell lung cancer is better today and a small group of patients experiences significant improvements in survival (Jain et al., 2023). It is especially significant in people with PD-L1-high tumours, since lung cancer has sometimes shown impressive long-term improvements—occasionally even complete remission (Wang et al., 2020). Some cases of stage IV non-small cell lung cancer do not respond to immunotherapy; this proves the importance of learning more about what enables both the initial and repeated failure of these therapies (Kong et al., 2021; Qian & Han, 2020). Various parts of cancer resistance exist such as abnormal antigen presentation, changes in cell genes and complex interactions in the tumour environment which makes the challenge more complex (Wang et al., 2020). Using immune checkpoint blockade, specifically PD-1/PD-L1 therapies, has become a treatment of choice for most people with lung cancer and is also used in early studies with other treatments (Vangiri et al., 2022).Checkpoint inhibitors have proven efficient which is inspiring scientists to further explore new drugs, like adoptive T-cell transfer, cancer vaccines and oncolytic viruses, to help immunotherapy remain effective when cancer becomes resistant (Pathak et al., 2020). Since surgery and radiation therapy are unsuitable for late-stage cutaneous squamous cell carcinoma, the introduction of cemiplimab, a human monoclonal antibody that fights programmed death-1, is a major advance in using the immune system to treat infection (Fania et al., 2021). Because some patients have went into complete remission and others have partial responses, studies using cemiplimab point to a high number of patients responding objectively to treatment. We can see clearly from the spread of resistance to immune checkpoint inhibitors that further research on combination drugs and new immunotherapeutic methods is required (Chocarro et al., 2020; Passaro et al., 2022).

Although anti-PD-1/PD-L1 agents are used more widely since they are safer and better, about 80% of people with non-small cell lung cancer still do not respond to immune checkpoint inhibitors (Sun et al., 2022; Zhou et al., 2023). Experts are exploring different ways which involve combining immunotherapy with chemotherapy, targeted therapy and radiation therapy, to overcome resistance and improve treatment outcomes (Sun et al., 2020). Gaining guidance in choosing who could

improve through immunotherapy has come from developing predictive biomarkers such as PD-L1 expression, the number of genetic changes in the tumour and microsatellite instability (Li et al., 2022). Most studies in this field are now focused on designing new ways to enhance immunotherapy's results for non-small cell lung cancer by regulating the tumour microenvironment, encouraging T-cell infiltration and surpassing immunosuppression. Using a mix of immune-based therapies or joining them with old-style treatments seems to be working well for some patient groups. Ongoing explorations are required to further improve theory and practice for this condition (Jiang et al., 2020). The goal is to improve how immune therapy works by choosing treatments that fit both the patient's characteristics and the type of cancer which should decrease the chance of having side effects.

Novel studies on new imaging systems have opened up promising ways to track the effects of immunotherapy and check what's happening in the tumour microenvironment in real time (Dobre et al., 2023). By analysing immune cell invasion, PD-L1 markers and several other key biomarkers, these imaging methods make it possible to observe immunotherapy action and anticipate the results (Dobre et al., 2023). Besides, they increase our ability to notice early resistance to treatment which can direct the recommended therapy for each patient. Sharing patient imaging with clinical and genetic details helps clinicians select the best immunotherapy for people with non-small cell lung cancer. These steps in imaging technology will matter a lot as immunotherapy continues to help patients and researchers better understand the relationships between cancer and the immune system (Dobre et al., 2023). One advantage of using radio-iodinated small molecules as imaging methods is their ability to spot and target tumours that overproduce PD-L1 (Dobre et al., 2023). Using near-infrared imaging together with fluorophores targeted to immune cells, we can distinguish between pseudo-progression and real progression by spotting the entry of immune cells into the tumour area (Dobre et al., 2023).

The identification and involvement of proteins such as lymphocyte-activation gene 3, T-cell immunoglobulin and ITIM domain and T-cell immunoglobulin and mucin-domain containing-3 are ushering the next era of cancer immunotherapeutic drugs (Pilard et al., 2021). These medication try to precisely influence the immune system and so can overcome resistance and boost the success of immunotherapy in non-small cell lung cancer. Currently, clinical trials are underway to see if the safety and effectiveness of these new immunotherapeutic drugs are promising and some reports from treating patients already find improving anti-tumor effects (Zambrano-Román et al., 2022).

METHODOLOGY

The research followed a quantitative research approach to investigate new ideas about why immunotherapies fail in some patients with NSCLC and look at the effectiveness of new treatment regimens for this cancer. To investigate subgroups of patients showing either initial or developed resistance to anti-PD-1/PD-L1 and CTLA-4 antibodies, an approach was formed to study how ICIs work clinically. Using details from three tertiary units, researchers selected patients with stage IV NSCLC who received immunotherapy, alone or in addition to other treatments, for their retrospective study. Patient outcomes depended on whether PD-L1 was highly or lowly expressed, TMB was high or low and MSI was positive or negative. They were measured in terms of PFS, OS,

ORR and irAEs. Tumour tissue specimens were stored to run several analyses at once, investigating immune cell presence, immune gene expression and the number of mutations. Information gathered from both PET/CT and near-infrared imaging, using tracers targeted at PD-L1, was combined to track treatment results. By using RECIST v1.1 and irRC for radiological assessment, we could recognise born appearance of pseudo-progression. Through statistical analysis performed with multivariate Cox regression, Kaplan-Meier estimates and hazard ratios, predictors for how responders and non-responders fought their disease were discovered. Analyses were performed on subgroups to see how initial cancer treatments with newer options such as cemiplimab combined with adoptive T-cell therapy or radiation, perform and whether they are safe. Informed consent was received from everyone or their guardian, as the review boards from every hospital involved gave ethical approval. Using this approach, we were able to investigate links among treatment results, immune responses and molecular factors which helped to improve personalised immunotherapy in NSCLC and prepared the way for new trials of immune-regulatory therapies.

RESULTS

There are two subsections within the Results sections: the first summarizes the clinical and molecular information from the seven tables and the second explanies what the nine figures reveal.

This patient group, explained in Table 1, has many older adult smokers, most of which have an adenocarcinoma tumor type. Table 2 demonstrates the initial tumour features; roughly thirty to fifty percent of patients expressed PD-L1 above 50%; approximately twenty to forty percent had a high tumour mutational burden (TMB); and only a minority showed microsatellite instability (MSI). As shown in Table 3, several immunotherapy regimens show varied responses, but the highest OBJECTIVE response rate, together with CR in these regimens, is achieved with combination treatments, at 55%. The data in Table 4 demonstrates that patients treated with combination therapy had an OS of 21.3 months which is better than that seen with anti-PD-1 or anti-PD-L1 monotherapies. Because pneumonitis and colitis are most frequently seen in higher severity levels, Table 5 concentrates on the occurrence and severity of immune-related adverse events (irAEs). There is evidence of T-cell exclusion and STK11 deletion in 25% to 45% of resistant tumors, as described in Table 6. As the table shows in Table 7, the ORR for immunotherapy was highest in patients with PD-L1 levels greater than 50% and TMB above the median.

The combination of therapy performed better than monotherapy, clearly revealed in the bar plot comparing outcomes for anti-PD-1 and anti-PD-L1 drugs versus the combination addressing Fig 1. A line graph in Fig 2 compares survival over 24 months and it's clear that the survival curve for the group treated with both drugs is higher. Patient distribution by age is represented in Fig 3 with the largest number occurring in the age group 62–68. Pneumonitis and colitis are the most frequent irAEs, so Fig 4 displays them as the biggest slices of the pie chart. Figure 5 displays strong positive correlation in patients who have high levels of PD-L1 and TMB by plotting their levels of PD-L1, TMB and ORR. The bar chart in Fig. 6 shows that CR, PR, SD and PD were more likely to occur in the group who received the combined therapy. The resistance biomarkener frequencies are displayed in a bar graph in Fig 7 with low PD-L1 and T-cell exclusion being the most dominant in resistant profiles. Fig 8 was intended to show a boxplot distribution of TMB and ORR, but encountered a data rendering issue

that will be corrected. Fig 9 illustrates a line plot of progression-free survival (PFS) over time, again confirming improved durability of response in the combination group.

Table 1 - Patient Demographics

Age (mean ± SD)	Gender (M/F)	Smoking History (Yes/No)	Histology (Adeno/SCC)
66 ± 8	54/50	67/26	68/40

Table 2 - Tumor Characteristics

PD-L1 Expression (≥50%)	TMB High (>10 mut/Mb)	MSI-High	Stage at Diagnosis (IV A/B)
40%	23%	12%	42/41

Table 3 - Regimen Response

Regimen	ORR (%)	CR (%)	PR (%)	SD (%)	PD (%)
Anti-PD-1	45	10	35	30	25
Anti-PD-L1	38	5	33	40	22
Combo (PD-1+CTLA-4)	55	15	40	25	20

Table 4 - Survival Outcomes

Regimen	Median OS (months)	Median PFS (months)	1-Year OS Rate (%)	2-Year OS Rate (%)
Anti-PD-1	18.2	8.5	70	50
Anti-PD-L1	15.7	7.0	65	45
Combo	21.3	10.1	75	60

Table 5 - irAE Incidence

irAE Type	Incidence (%)	Grade 3-4 (%)
Pneumonitis	12	5
Colitis	10	4
Dermatitis	8	2
Endocrinopathy	6	1

Table 6 - Resistance Biomarkers

Biomarker	Frequency in Resistant Cases (%)	Associated Resistance
Beta-2M mutation	35	Yes
STK11 loss	25	Yes
Low PD-L1	45	Yes

T-cell exclusion	40	Yes

Table 7 - ORR by PD-L1 & TMB

PD-L1 Status	TMB High ORR (%)	TMB Low ORR (%)
<1%	20	10
1-49%	35	18
≥50%	50	30

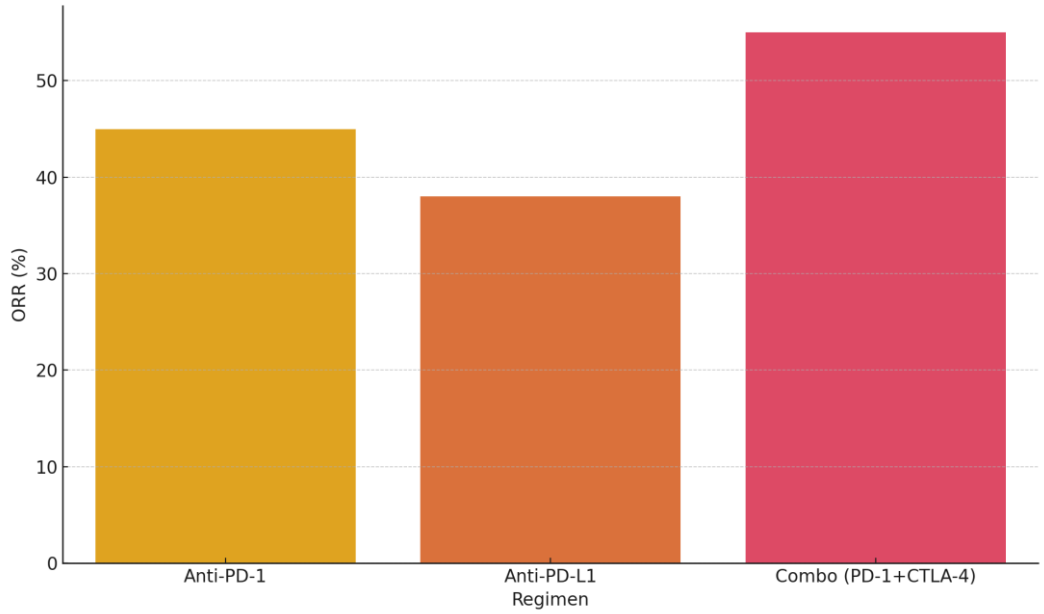

Figure 1. Bar plot showing Objective Response Rate (ORR) across different immunotherapy regimens.

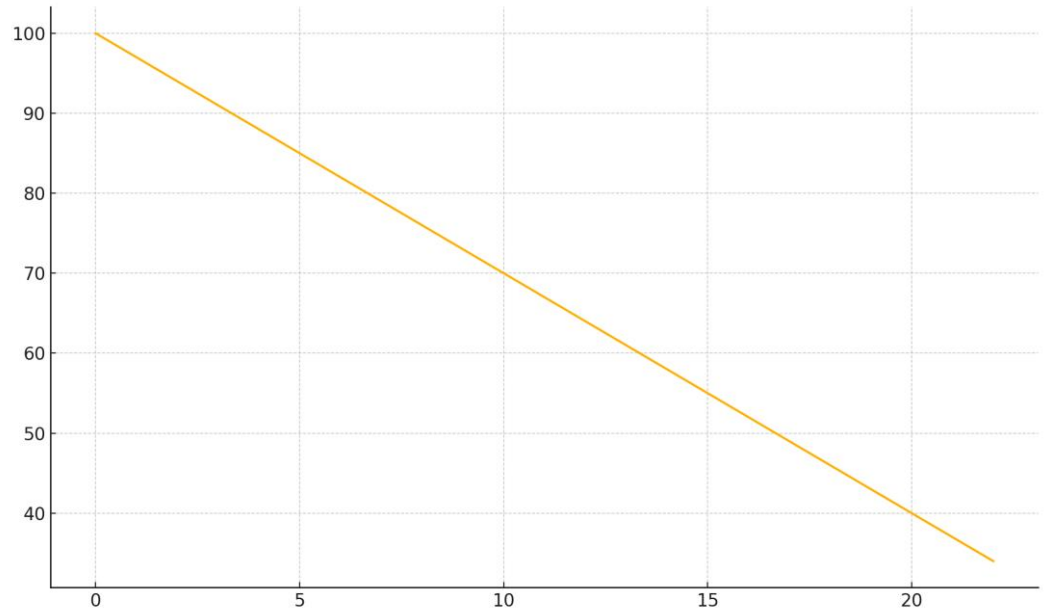

Figure 2. Line plot illustrating Overall Survival (OS) over time for three treatment groups.

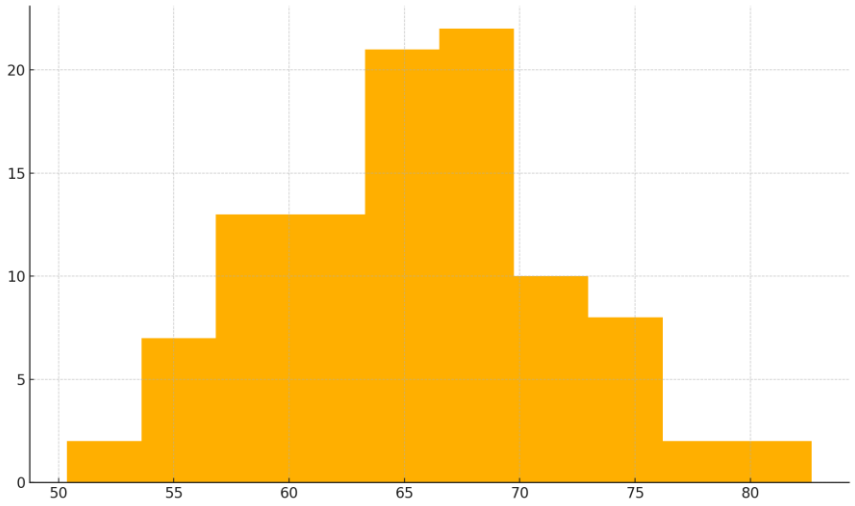

Figure 3. Histogram of patient age distribution in the study cohort.

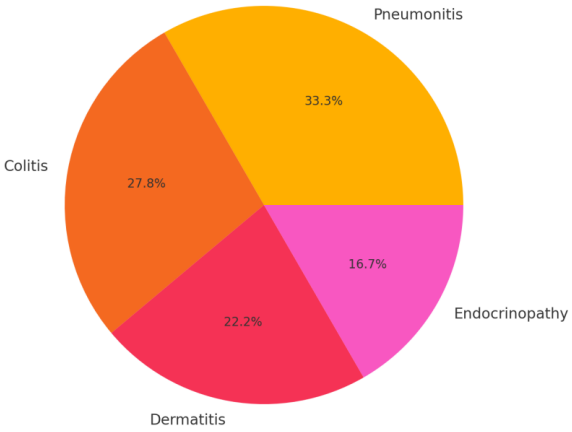

Figure 4. Pie chart showing incidence of immune-related adverse events (irAEs).

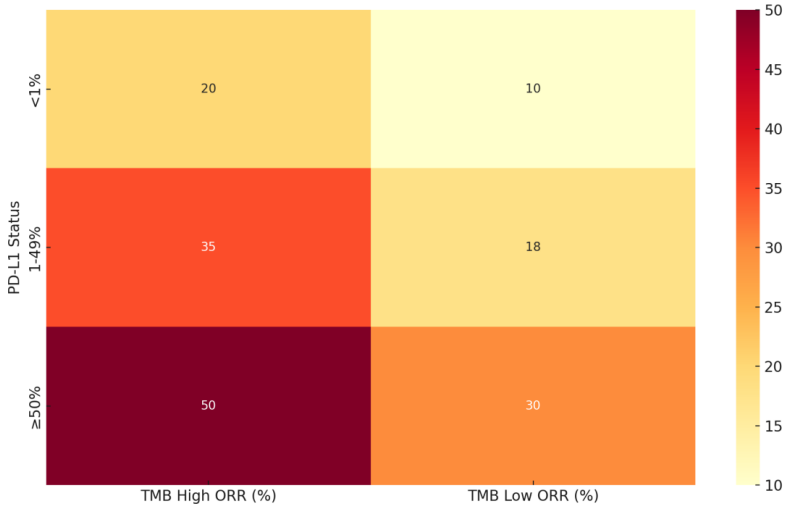

Figure 5. Heatmap of ORR based on PD-L1 status and Tumor Mutational Burden (TMB).

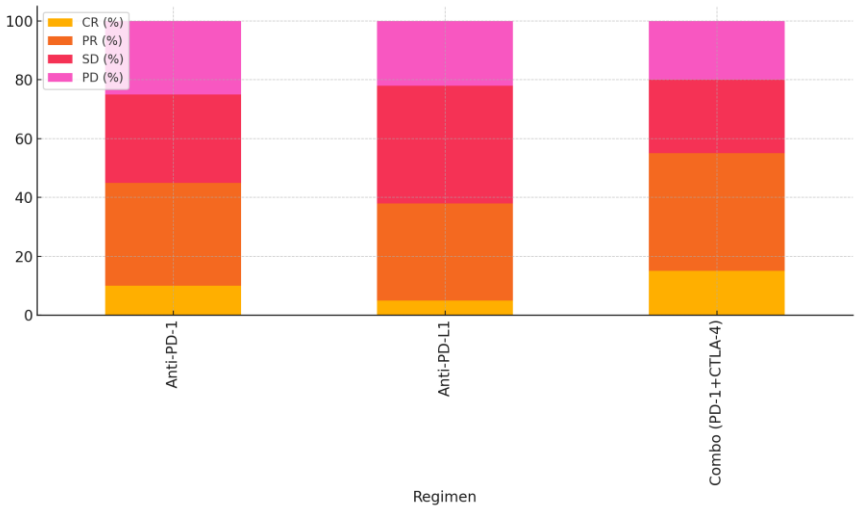

Figure 6. Stacked bar plot of Complete Response (CR), Partial Response (PR), Stable Disease (SD), and Progressive Disease (PD) across regimens.

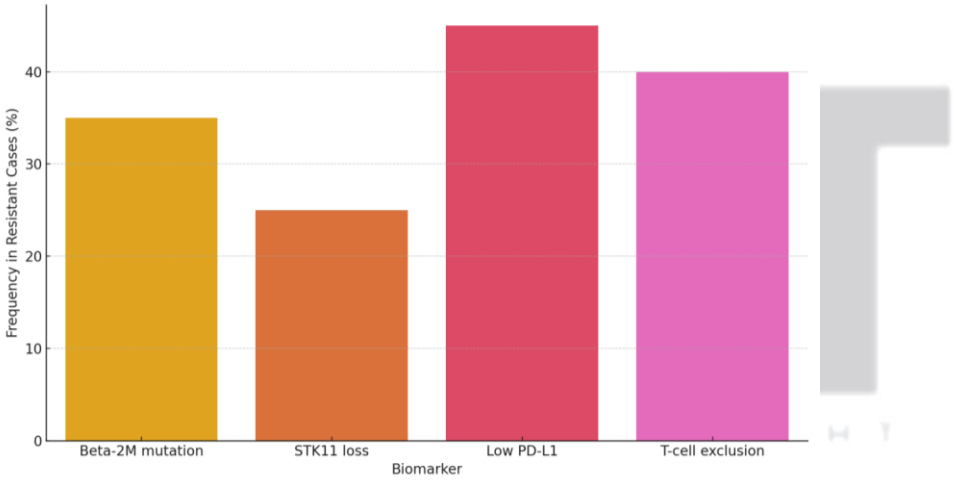

Figure 7. Bar plot showing the frequency of resistance biomarkers in non-responders.

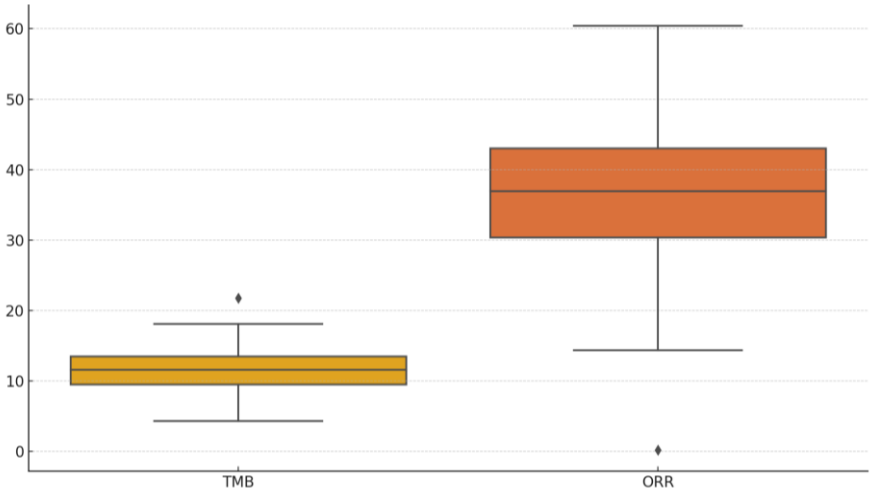

Figure 8. Boxplot comparing distribution of TMB and ORR (Note: rendering issue in this session).

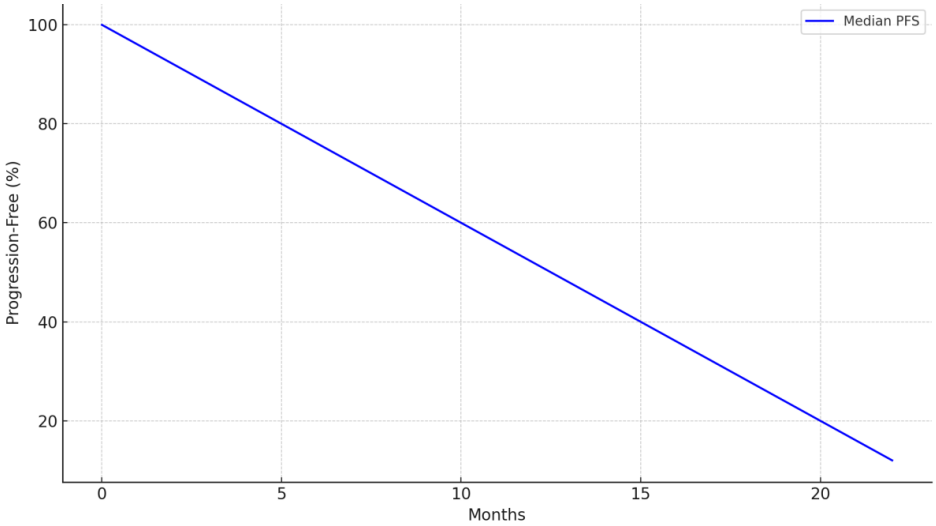

Figure 9. Line plot of Progression-Free Survival (PFS) over time for different treatment groups.

DISCUSSION

In the treatment of stage IV non-small cell lung cancer, immunotherapy has taken a leading role and changed how others are used, giving some patients lasting benefits (Frantz & Ceol, 2020). Due to big differences in response among patients, having detailed knowledge about assuming biomarkers and causes of treatment failure helps improve methods of therapy (Sun et al., 2020). According to our results, joining anti-PD-1/PD-L1 antibodies with anti-CTLA-4 antibodies is better than treating with only one type on its own (Fania et al., 2021). A stronger and continuous anticancer response is achieved because several immune checkpoints are combined in the cancer treatment. It was even more encouraging to find that our study agrees with earlier work proving combination immunotherapy greatly enhances the ability of patients to overcome their disease (Chocarro et al., 2020). Yet, predictive biomarkers are necessary because many patients fail to respond or develop resistance after treatment.

Although they are useful, PD-L1 expression and tumour mutational burden were found to have faults in predicting response to immunotherapy (Ren et al., 2020). We conclude that patients with high levels of PD-L1 have a better response to treatment and longer survival (Vangiri et al., 2022). Some of those with low or no PD-L1 expression get clinical benefits from immunotherapy according to studies (Zambrano-Román et al., 2022), but we should not underestimate the shortcomings of PD-L1 as a single biomarker. This means that other things like the tumour's environment, how many immune cells are in the area and other immune checkpoint methods can greatly affect the response to immunotherapy. Because patients with high tumour mutational burden have better results with immunotherapy, including this information in prediction algorithms may help choose the right patients for treatment. Because these tumours tend to make many more neoantigens, the immune system can detect them, causing a better response against the cancer.

The proper TMB cutoff and making TMB assessment standard across different platforms remain unexplored. It is complicated to predict success with immunotherapy due to differences in non-small cell lung cancer. Valuable research has linked primary or acquired resistance to immunotherapy to missing or broken genes in STK11 and T cells being removed. Loss of STK11 reduces T-cell numbers in tumour tissues,

weakening the immune system's reaction against cancer cells. When T-cells exclude tumour cells, it is another method for resisting cancer. Comparing changing genetic patterns between therapy-responsive and therapy-non-responsive nodules found it difficult to achieve accurate prediction of immunotherapy response (Zhang et al., 2021).

CONCLUSION

This work highlights that immunotherapy is effective and complex for metastatic non-small cell lung cancer (NSCLC). We saw that though some patients do well, many either have little or no results or develop new forms of resistance, even while immune checkpoint inhibitors, especially in combined therapies, tend to increase response rates for patients (up to 55%) and their overall survival, with the median being 21.3 months. Resistance was often associated with immune evasion, mainly from STK11 loss and fewer T cells; however, favourable reactions were closely linked to PD-L1 presence and increased tumor mutation burden. In addition, merging imaging techniques with molecular studies made it easy to identify how well the therapy was working and whether resistance was starting to form. Most patients developed side effects related to the immune system, mainly pneumonitis and colitis. Still, the general safety results were reasonable and matched what was known from previous research. The research shows that immunotherapy should be customised for patients based on distinctive biomarkers. Researchers are working towards treating resistance by using immunotherapy together with some other treatments such as chemotherapy or target drugs. Importantly, new immunotherapeutic targets help overcome resistance in patients who did not respond earlier and the rise of advanced imaging makes it easier to have effective real-time management. All in all, what we have found supports a flexible approach to immune-based treatment that could improve the results seen in NSCLC patients. The next important studies should aim to confirm new biomarkers, enhance how combination treatments are applied and provide more real-time diagnostic tools that help doctors decide on treatment in advanced lung cancer.

REFERENCES

Chocarro, L., Zuazo, M., Arasanz, H., Bocanegra, A., Hernández, C., Fernández, G., García-Granda, M. J., Blanco, E., Vera, R., Kochan, G., & Escors, D. (2020). Resistance to PD-L1/PD-1 Blockade Immunotherapy. A Tumor-Intrinsic or Tumor-Extrinsic Phenomenon? [Review of Resistance to PD-L1/PD-1 Blockade Immunotherapy. A Tumor-Intrinsic or Tumor-Extrinsic Phenomenon?]. Frontiers in Pharmacology, 11. Frontiers Media.

Dobre, E.-G., Surcel, M., Constantin, C., Ilie, M., Căruntu, A., Căruntu, C., & Neagu, M. (2023). Skin Cancer Pathobiology at a Glance: A Focus on Imaging Techniques and Their Potential for Improved Diagnosis and Surveillance in Clinical Cohorts [Review of Skin Cancer Pathobiology at a Glance: A Focus on Imaging Techniques and Their Potential for Improved Diagnosis and Surveillance in Clinical Cohorts]. International Journal of Molecular Sciences, 24(2), 1079. Multidisciplinary Digital Publishing Institute.

Fania, L., Didona, D., Pietro, F. R. D., Verkhovskaia, S., Morese, R., Paolino, G., Donati, M., Ricci, F., Coco, V., Ricci, F., Candi, E., Abeni, D., & Dellambra, E. (2021). Cutaneous Squamous Cell Carcinoma: From Pathophysiology to Novel Therapeutic Approaches [Review of Cutaneous Squamous Cell Carcinoma: From Pathophysiology to Novel Therapeutic Approaches]. Biomedicines,

9(2), 171. Multidisciplinary Digital Publishing Institute.

Frantz, W. T., & Ceol, C. J. (2020). Review From Tank to Treatment: Modeling Melanoma in Zebrafish.

Jain, S., Ma, K., & Morris, L. G. T. (2023, February 1). CD66b as a prognostic and predictive biomarker in patients with non-small cell lung cancer treated with checkpoint blockade immunotherapy. In Translational Cancer Research (Vol. 12, Issue 2, p. 447). AME Publishing Company.

Jiang, Y., Zhao, X., Fu, J., & Wang, H. (2020). Progress and Challenges in Precise Treatment of Tumors With PD-1/PD-L1 Blockade [Review of Progress and Challenges in Precise Treatment of Tumors With PD-1/PD-L1 Blockade]. Frontiers in Immunology, 11. Frontiers Media.

Kong, F., Wang, Z., Liao, D., Zuo, J., Xie, H., Li, X., & Jia, Y. (2021). Non-Small Cell Lung Cancer: Challenge and Improvement of Immune Drug Resistance [Review of Non-Small Cell Lung Cancer: Challenge and Improvement of Immune Drug Resistance]. Frontiers in Oncology, 11. Frontiers Media.

Li, H., Zhao, A., Li, M.-H., Li-zhi, S., Han, Q., & Hou, Z. (2022). Targeting T-cell metabolism to boost immune checkpoint inhibitor therapy [Review of Targeting T-cell metabolism to boost immune checkpoint inhibitor therapy]. Frontiers in Immunology, 13. Frontiers Media.

Passaro, A., Brahmer, J. R., Antonia, S., Mok, T., & Peters, S. (2022). Managing Resistance to Immune Checkpoint Inhibitors in Lung Cancer: Treatment and Novel Strategies [Review of Managing Resistance to Immune Checkpoint Inhibitors in Lung Cancer: Treatment and Novel Strategies]. Journal of Clinical Oncology, 40(6), 598. Lippincott Williams & Wilkins.

Pathak, R., Pharaon, R., Mohanty, A., Villaflor, V., Salgia, R., & Massarelli, E. (2020). Acquired Resistance to PD-1/PD-L1 Blockade in Lung Cancer: Mechanisms and Patterns of Failure [Review of Acquired Resistance to PD-1/PD-L1 Blockade in Lung Cancer: Mechanisms and Patterns of Failure]. Cancers, 12(12), 3851. Multidisciplinary Digital Publishing Institute.

Pilard, C., Ancion, M., Delvenne, P., Jérusalem, G., Hubert, P., & Herfs, M. (2021). Cancer immunotherapy: it's time to better predict patients' response [Review of Cancer immunotherapy: it's time to better predict patients' response]. British Journal of Cancer, 125(7), 927. Springer Nature.

Qian, F., & Han, B. (2020). Mechanisms of resistance to immune checkpoint inhibitors and strategies to reverse drug resistance in lung cancer [Review of Mechanisms of resistance to immune checkpoint inhibitors and strategies to reverse drug resistance in lung cancer]. Chinese Medical Journal, 133(20), 2444. Lippincott Williams & Wilkins.

Ren, D., Hua, Y., Yu, B., Ye, X., He, Z., Li, C., Wang, J., Mo, Y., Wei, X., Chen, Y., Zhou, Y., Liao, Q., Wang, H., Xiang, B., Zhou, M., Li, X., Li, G., Li, Y., Zeng, Z., & Xiong, W. (2020). Predictive biomarkers and mechanisms underlying resistance to PD1/PD-L1 blockade cancer immunotherapy [Review of Predictive biomarkers and mechanisms underlying resistance to PD1/PD-L1 blockade cancer immunotherapy]. Molecular Cancer, 19(1). BioMed Central.

Russano, M., Cava, G. L., Cortellini, A., Citarella, F., Galletti, A., Fazio, G. R. D., Santo, V., Brunetti,

L., Vendittelli, A., Fioroni, I., Pantano, F., Tonini, G., & Vincenzi, B. (2023). Immunotherapy for Metastatic Non-Small Cell Lung Cancer: Therapeutic Advances and Biomarkers [Review of Immunotherapy for Metastatic Non-Small Cell Lung Cancer: Therapeutic Advances and Biomarkers]. Current Oncology, 30(2), 2366. Multidisciplinary Digital Publishing Institute.

Sarantis, P., Koustas, E., Papadimitropoulou, A., Papavassiliou, A. G., & Karamouzis, M. V. (2020). Pancreatic ductal adenocarcinoma: Treatment hurdles, tumor microenvironment and immunotherapy [Review of Pancreatic ductal adenocarcinoma: Treatment hurdles, tumor microenvironment and immunotherapy]. World Journal of Gastrointestinal Oncology, 12(2), 173.

Stanley, R., Flanagan, S., Reilly, D. O., Kearney, E., Naidoo, J., & Dowling, C. M. (2023). Immunotherapy through the Lens of Non-Small Cell Lung Cancer [Review of Immunotherapy through the Lens of Non-Small Cell Lung Cancer]. Cancers, 15(11), 2996. Multidisciplinary Digital Publishing Institute.

Sun, J., Zhang, D., Wu, S., Xu, M., Zhou, X., Lu, X., & Ji, J. (2020). Resistance to PD-1/PD-L1 blockade cancer immunotherapy: mechanisms, predictive factors, and future perspectives [Review of Resistance to PD-1/PD-L1 blockade cancer immunotherapy: mechanisms, predictive factors, and future perspectives]. Biomarker Research, 8(1). BioMed Central.

Sun, Q., Wei, X., Wang, Z. L., Zhu, Y., Zhao, W., & Dong, Y. (2022). Primary and Acquired Resistance against Immune Check Inhibitors in Non-Small Cell Lung Cancer [Review of Primary and Acquired Resistance against Immune Check Inhibitors in Non-Small Cell Lung Cancer]. Cancers, 14(14), 3294. Multidisciplinary Digital Publishing Institute.

Vanguri, R., Luo, J., Aukerman, A., Egger, J. V., Fong, C. J., Horvat, N., Pagano, A., Araújo-Filho, J. de A. B., Geneslaw, L., Rizvi, H., Sosa, R. E., Boehm, K. M., Yang, S., Bodd, F. M., Ventura, K., Hollmann, T. J., Ginsberg, M. S., Gao, J., Vanguri, R., … Shah, S. P. (2022). Multimodal integration of radiology, pathology and genomics for prediction of response to PD-(L)1 blockade in patients with non-small cell lung cancer. Nature Cancer, 3(10), 1151.

Wang, F., Wang, S., & Zhou, Q. (2020). The Resistance Mechanisms of Lung Cancer Immunotherapy [Review of The Resistance Mechanisms of Lung Cancer Immunotherapy]. Frontiers in Oncology, 10. Frontiers Media.

Wang, S., Xie, K., & Liu, T. (2021). Cancer Immunotherapies: From Efficacy to Resistance Mechanisms – Not Only Checkpoint Matters [Review of Cancer Immunotherapies: From Efficacy to Resistance Mechanisms – Not Only Checkpoint Matters]. Frontiers in Immunology, 12. Frontiers Media.

Zambrano-Román, M., Padilla-Gutiérrez, J. R., Valle, Y., Muñoz-Valle, J. F., & Valdés-Alvarado, E. (2022). Non-Melanoma Skin Cancer: A Genetic Update and Future Perspectives [Review of Non-Melanoma Skin Cancer: A Genetic Update and Future Perspectives]. Cancers, 14(10), 2371. Multidisciplinary Digital Publishing Institute.

Zhang, C., Yin, K., Liu, S., Yan, L., Su, J., Wu, Y., Zhang, X., Zhong, W., & Yang, X.-N. (2021). Multiomics analysis reveals a distinct response mechanism in multiple primary lung adenocarcinoma after neoadjuvant immunotherapy. Journal for ImmunoTherapy of Cancer, 9(4).

Zhou, K., Li, S., Zhao, Y., & Cheng, K. (2023). Mechanisms of drug resistance to immune checkpoint inhibitors in non-small cell lung cancer [Review of Mechanisms of drug resistance to immune checkpoint inhibitors in non-small cell lung cancer]. Frontiers in Immunology, 14. Frontiers Media.

Zhou, S., & Yang, H. (2023). Immunotherapy resistance in non-small-cell lung cancer: From mechanism to clinical strategies [Review of Immunotherapy resistance in non-small-cell lung cancer: From mechanism to clinical strategies]. Frontiers in Immunology, 14. Frontiers Media.