

Background

Atelectasis, defined as the loss of lung volume due to alveolar deflation, develops in nearly 90% of patients under general anesthesia.¹ It is associated with increased risk of impaired gas exchange, pneumonia, and acute lung injury.² High frequency jet ventilation (HFJV) delivers very low tidal volumes at 100-150 breaths per minute, and is employed in procedures requiring minimal respiratory motion, such as percutaneous liver tumor ablations.³ The reduced movement offered by HFJV allows for increased precision and more accurate placement of the ablation probe. Although HFJV has been explored for its potential to reduce atelectasis, direct quantitative comparisons between HFJV and conventional ventilation in terms of atelectasis formation are still limited.⁴ This study seeks to provide a quantitative assessment of atelectasis development under HFJV compared to conventional ventilation, aiming to inform improvements in perioperative respiratory management. Our hypothesis is that HFJV will not worsen the formation of atelectasis when compared to conventional ventilation.

Objective

To determine if there is any significant difference in the formation of atelectasis between patients receiving general anesthesia with HFJV and conventional ventilation during percutaneous liver tumor ablation.

Study Design

This retrospective, observational study included 26 BMI-matched patients who underwent CT-guided microwave liver tumor ablations at MD Anderson between June 2023 and December 2024.

HFJV Group: 12 patients received HFJV

Conventional Ventilation Group: 14 patients received standard ventilation with breath holds

Patient demographics are summarized in Table 1.

		Control	Jet	Overall
Age	Median	54.5 (45-71)	60.5 (43-74)	55.5 (43-75)
Sex	Male	9	10	19
	Female	5	2	7
BMI	Average	29.21	29.2	29.21

Table 1 Patient Demographics

Methods

Ventilation

A Monsoon 3 high frequency jet ventilator (HFJV) was used (Fig 1).

CT Imaging & Analysis

Two CT scans per patient were analyzed

- CT 1:** Acquired shortly after HFJV or conventional positive pressure ventilation initiation
- CT 2:** Acquired ~1 hour later

Scans were imported into RayStation. Lung volumes were segmented using RayStation’s deep learning segmentation tool and subsequently manually corrected for artifacts. Atelectatic regions were defined as lung tissue between -100 Hounsfield Units (HU) and +100 HU, based on published criteria.⁵ A custom script calculated the percentage of atelectasis using this criteria.

Statistical Analysis

All analyses were done in RStudio. Normality was assessed for with the Shapiro Wilks test. Differences between CT 1 and CT 2, and HFJV and conventional ventilation were examined using the Wilcoxon signed-rank tests.



Fig. 1 The Monsoon 3 High Frequency Jet Ventilator⁶

Results

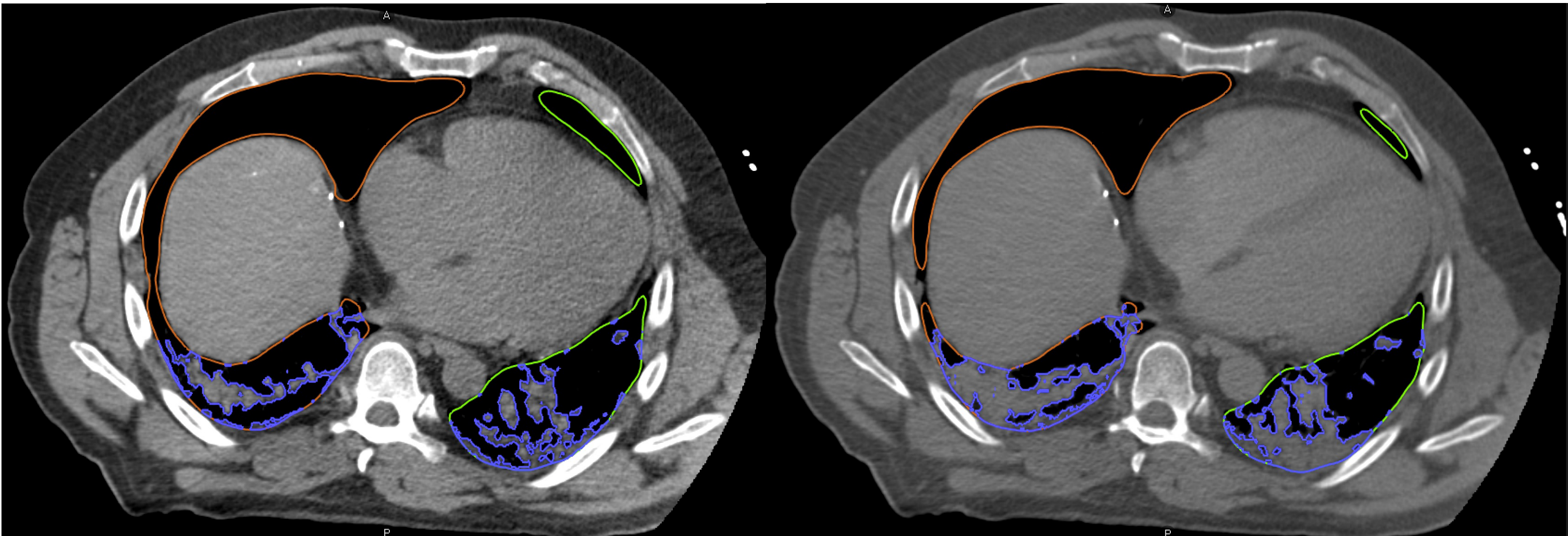


Fig. 2
Ex of CT
1 and
CT 2

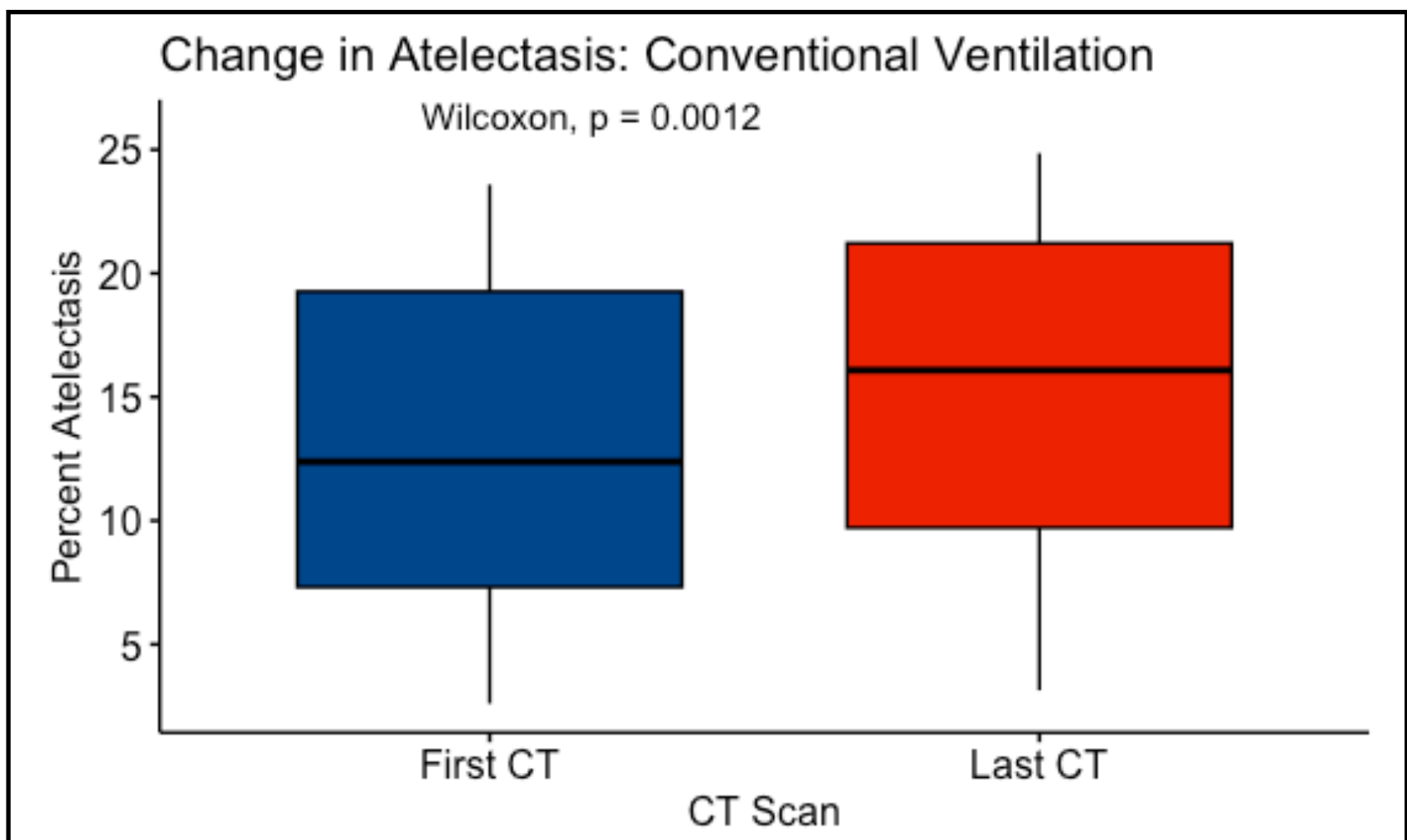


Fig. 3 Boxplot of the atelectasis progress between CT 1 and CT 2 for patients who received conventional ventilation. There is a statistically significant difference in the percent atelectasis between the first and last CT scans (p = 0.0012).

■ R Lung
■ L Lung
■ Atelectasis

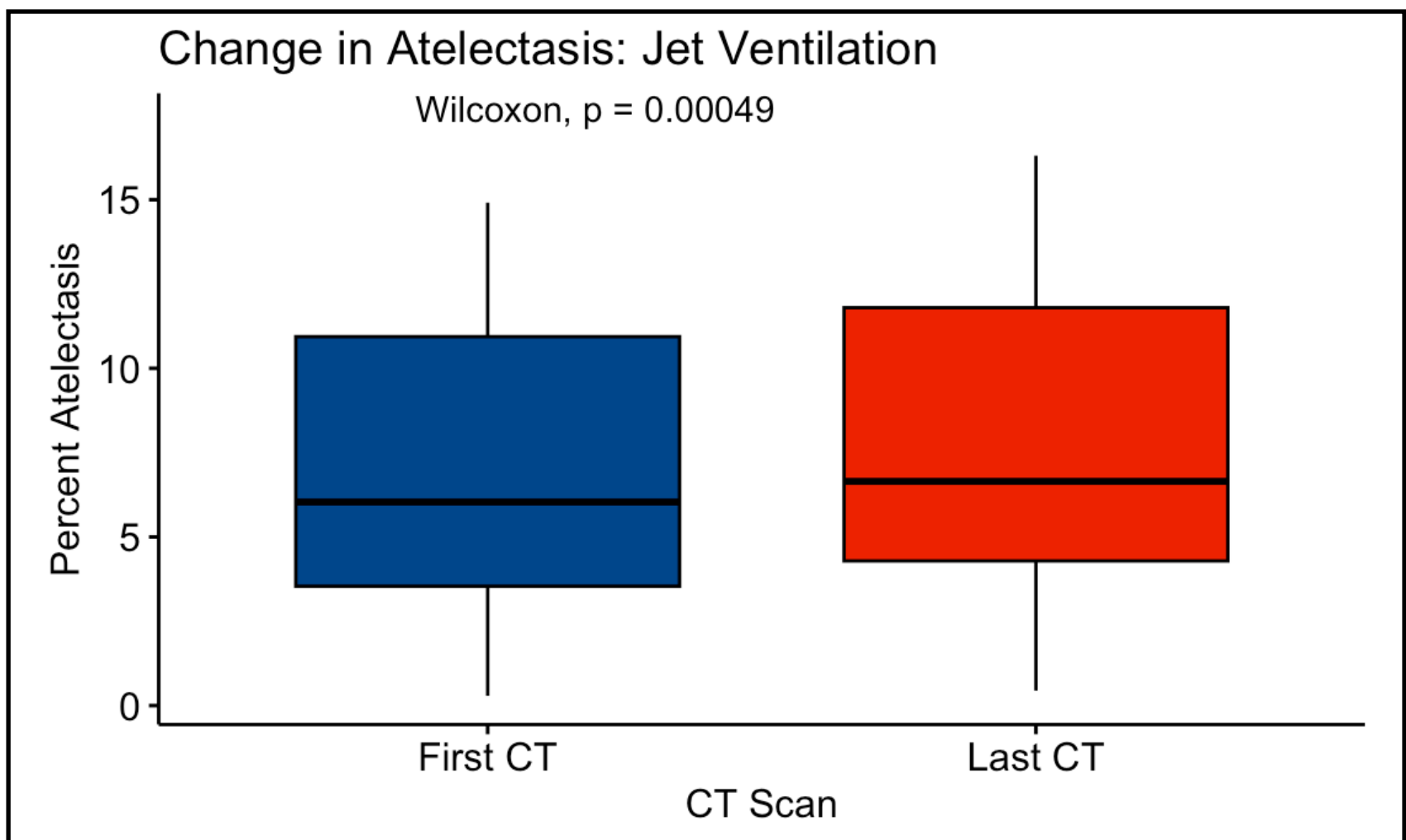


Fig. 4 Boxplot of the atelectasis progress between CT 1 and CT 2 for patients who received high frequency jet ventilation. There is a statistically significant difference in the percent atelectasis between the first and last CT scans (p = 0.00049).

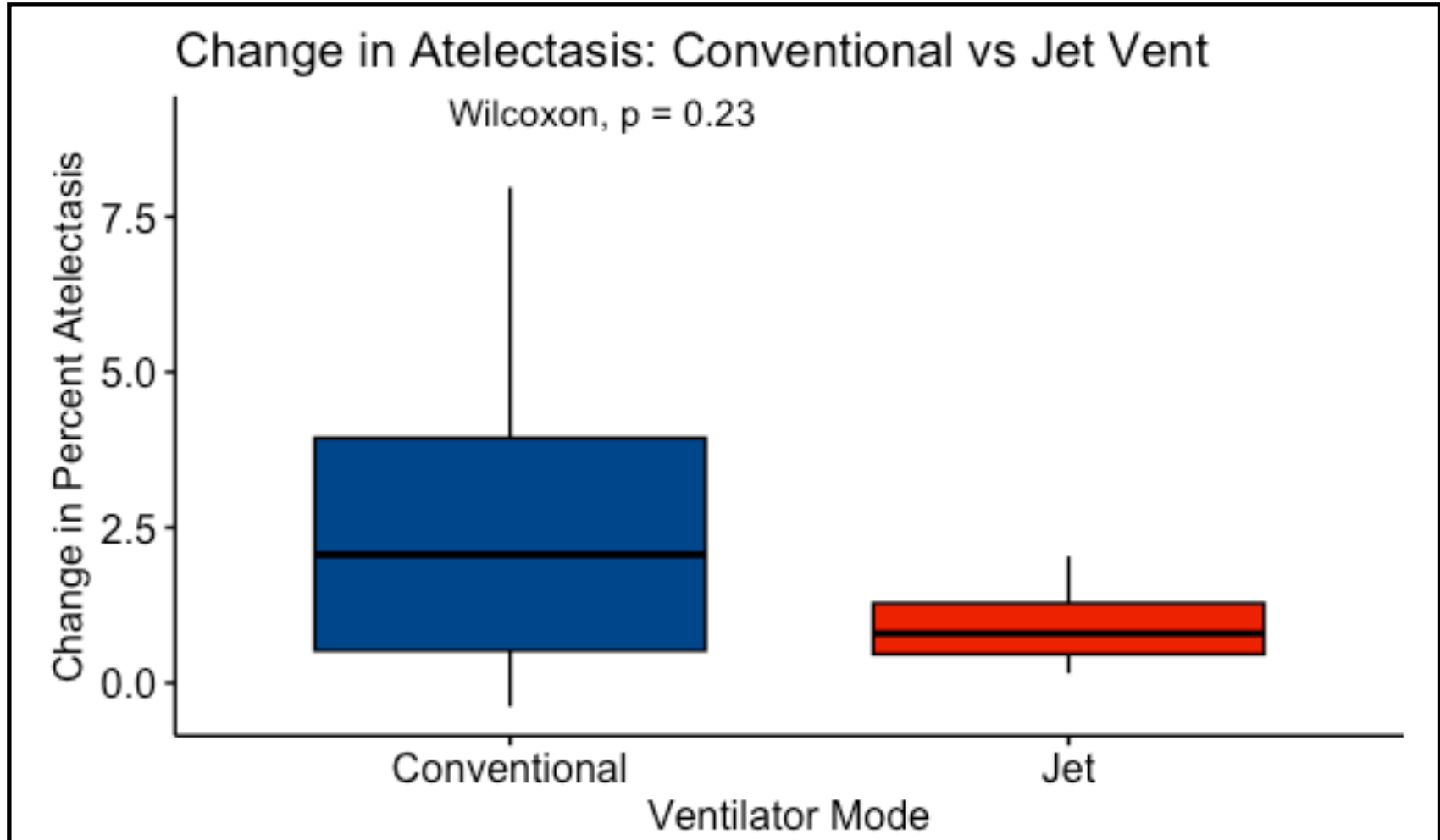


Fig. 5 Boxplot comparing the atelectasis progress between patients who received conventional ventilation and patients who received high frequency jet ventilation. There is not a statistically significant difference (p = 0.23).

Discussion

Both conventional ventilation with breath holds and HFJV resulted in worsening atelectasis over the course of one hour under general anesthesia with endotracheal intubation. This was found to be statistically significant and corresponds with existing literature. While conventional ventilation resulted in a larger increase of atelectasis (Average = +2.45% and Median = +2.06%) when compared to HFJV (Average = +0.89% and Median = +0.79%), this difference was not found to be statistically significant (p-value = 0.23). Despite this, it is possible that this difference is clinically significant. Furthermore, the main benefit of HFJV remains the minimization of patient chest wall movement, which allows for improved probe placement accuracy. Our results show promise that HFJV does not worsen the development of atelectasis under general anesthesia when compared to conventional ventilation.

Limitations and Future Studies

The main limitation of this study is the small sample size and retrospective design. Future studies should include more patients and be prospective and randomized in order to better control for variables such as patient demographics and jet ventilation settings. Another limitation of the study is the possibility of human error occurring during manual correction. Future studies should employ more interpretations of each CT scan done by other medical professionals so an average can be used. Finally, future studies should also address the confounding variable of breath holds and how they can contribute to atelectasis.

References

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