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ORIGINAL RESEARCH

Short-Term Outcomes of Bronchoscopic Thermal Vapor Ablation in Patients with Severe COPD: A Case Series from a Single Chinese Center

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Background and Objective: Bronchoscopic Thermal Vapor Ablation (BTVA) is a novel endoscopic lung volume reduction (ELVR) technique designed to target emphysematous segments and reduce lung hyperinflation, especially in patients with heterogeneous emphysema. Although previous studies have demonstrated its efficacy in Western populations, data regarding BTVA outcomes in Asian cohorts remain limited. This study aimed to evaluate the short-term efficacy and safety of BTVA in patients with severe COPD in a real-world clinical setting.

Methods: This single-center, retrospective, observational study included 8 patients with advanced COPD who underwent BTVA at the Eighth Affiliated Hospital of Sun Yat-sen University between May 2023 and December 2024. Pulmonary function (FEV_1, FVC, FEV_1/FVC), 6-minute walk distance (6MWD), dyspnea scores (mMRC, CAT), and CT-based lung volume changes were assessed at baseline and at 1, 3, and 6 months post-treatment. Procedure-related adverse events were monitored for 1 month, and all patients were followed up for 6 months.

Results: All patients completed the 6-month follow-up. Significant improvements in FEV_1, FVC, 6MWD, and clinical symptoms (CAT and mMRC) were observed as early as 1 month post-BTVA and were sustained through 6 months. Although FEV_1/FVC showed no statistically significant change at 1 and 3 months, a significant increase was detected by month 6. CT imaging at 6 months revealed a marked reduction in the targeted lung volume from 707.5 ± 115.74 mL to 335.5 ± 129.59 mL. No severe adverse events were reported.

Conclusion: BTVA appears to be a safe and effective minimally invasive intervention for selected patients with advanced COPD, leading to significant short-term improvements in lung function, exercise capacity, and hyperinflation. These findings support the clinical utility of BTVA in Asian populations, although larger prospective studies are needed to confirm long-term benefits and assess repeatability.

Keywords: COPD, bronchoscopic thermal vapor ablation, emphysema, endoscopic lung volume reduction, interventional pulmonology

Introduction

Chronic obstructive pulmonary disease (COPD), characterized by emphysema and airflow limitation, is increasingly prevalent worldwide.[1,2] The treatment strategy for COPD primarily focuses on symptom management and slowing disease progression.[3] Surgical interventions and bronchoscopic lung volume reduction (BLVR) have been shown to significantly improve pulmonary function, reduce dyspnea, and enhance quality of life, particularly in patients with emphysema and pulmonary hyperinflation.[4] However, the benefits of some lung volume reduction (LVR) surgeries may be transient. Among the most studied LVR procedures, lung volume reduction surgery (LVRS) has demonstrated notable improvements in patients with emphysema, especially those with heterogeneous emphysema and upper lobe predominance. Despite these benefits, the high mortality and complication rates associated with LVRS have limited its application in the treatment of severe

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emphysema.[5,6] As a result, the GOLD guidelines recommend BLVR as an alternative approach for reducing mortality and morbidity, providing an effective treatment option for COPD patients.[7]

Among bronchoscopic techniques, endobronchial valves (EBV) are the most widely established and have consistently demonstrated improvements in lung function, exercise capacity, and quality of life in selected patients with heterogeneous emphysema and intact interlobar fissures.[8] Other approaches, such as endobronchial coils and sealants, have also been evaluated but are less frequently used due to safety concerns and variable efficacy.[9] These advances highlight the clinical value of BLVR while also underscoring the need for additional options for patients who are unsuitable for current methods.

Bronchoscopic thermal vapor ablation (BTVA) is a type of endoscopic lung volume reduction ELVR technique designed to reduce the volume of emphysematous lung segments by inducing localized inflammation through thermal injury via steam.[10,11] This technique is particularly beneficial for patients with severe upper lobe predominant heterogeneous emphysema, regardless of the presence of collateral ventilation (CV).[12,13] Initial clinical studies conducted in Western countries have shown that BTVA can improve lung function and exercise capacity. However, the efficacy of this novel treatment modality remains insufficiently evaluated in Asian populations.[14] Additionally, while BTVA is a minimally invasive and potentially cost-effective option, there is a lack of sufficient clinical trial data to confirm its long-term efficacy and safety. The objective of this study was to provide additional clinical and safety data regarding the use of BTVA as a treatment option for patients with COPD.

Methods

This is a single-center, retrospective, observational study designed to assess the efficacy and safety of Bronchoscopic Thermal Vapor Ablation (BTVA) in patients with COPD. The study was conducted at the Eighth Affiliated Hospital of Sun Yat-sen University from May 2023 to December 2024.

Study Population

The study included all COPD patients who underwent BTVA treatment at the Eighth Affiliated Hospital of Sun Yat-sen University and met the inclusion criteria, with no exclusion criteria applied.

Data Collection

Data were collected at baseline, 1 month, 3 months, and 6 months post-procedure. The primary outcome measures included the 6-Minute Walk Distance (6MWD), COPD Assessment Test (CAT), Modified Medical Research Council (mMRC) dyspnea scale, Forced Vital Capacity (FVC), FEV_1% and FEV_1/FVC ratio, as well as changes in lung volume as assessed by CT imaging. CT volumetric measurements were obtained using syngo.via (Siemens Healthineers, Erlangen, Germany), which allows semi-automated segmentation of targeted lung segments. All results were independently reviewed by two radiologists, and manual corrections were performed when necessary to improve accuracy. Procedure-related adverse events were recorded from the date of the procedure until 1 month post-procedure, and hospital admissions were tracked throughout the follow-up period. This study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board (IRB) of the Eighth Affiliated Hospital of Sun Yat-sen University (IRB approval number: 2023–114-02). A waiver of informed consent was granted by the IRB due to the retrospective nature of the study, and patient data confidentiality was strictly protected in accordance with institutional and ethical guidelines.

Statistical Methods

Improvement indicators were compared to baseline values. Data were analyzed using one-way analysis of variance (ANOVA). P-values are shown in the corresponding figures to indicate statistical significance.

BTVA Procedure

The targeted region for BTVA was determined using the InterVapor Personalized Procedure Program (IP3, Uptake Medical B.V., the Netherlands), which measures the tissue mass and air volume of each lung segment and identifies the segment with the most severe emphysema. The target regions for BTVA were selected based on quantitative CT analysis and perfusion assessment. The most emphysematous and hyperinflated areas were identified as treatment targets, primarily located in the upper lobes. This selection strategy followed standard BTVA procedural protocols to achieve

optimal volume reduction while minimizing the risk of post-procedural inflammation. The target energy level was set at 8.5 calories per gram of lung tissue. Water vapor was delivered via a bronchoscope into the bronchus of the targeted region. A balloon at the tip of the catheter was inflated to occlude the target area, and water vapor was delivered for 3–10 seconds. After the predetermined dose of vapor was delivered, the balloon was deflated, the vapor catheter was removed, and treatment was completed once the bronchoscope confirmed the absence of local bleeding. Patients were observed for 3–5 days post-procedure, and discharge decisions were made based on their clinical status.

Results

A total of 8 patients from the Eighth Affiliated Hospital of Sun Yat-sen University were enrolled in this study. The cohort had a mean age of 65.75 ± 5.3 years, with 7 patients (87.5%) being male (Table 1). Pulmonary function and clinical parameters were recorded at baseline and at 1, 3, and 6 months post-procedure. Additionally, smoking history and post-procedural adverse events were documented. No severe adverse events were observed. Minor complications included

Table 1 Characteristics of the Total Patients (n=8)

Demographic Features	Values
Age (years)	65.75±5.3
Male (%)	7(87.5)
Smoking history (%)	6 (75)
Adverse event after surgery: transient fever (%)	3(37.5)
Adverse event after surgery: cough (%)	6(75)
Adverse event after surgery: mild inflammatory (%)	2(25)
Pulmonary function	
FEV_1 (L)-Basal	31.46 ± 6.52
FEV_1 (L)-Post treatment	39.35 ± 7.32
FVC (L)-Basal	1.62 ± 0.56
FVC (L)-Post treatment	2.13 ± 0.56
FEV1/FVC-Basal	46.93 ± 7.85
FEV1/FVC-Post treatment	51.93 ± 7.35
RV (L)-Basal	4.00 ± 0.55
RV (L)-Post treatment	3.45 ± 0.50
TLC (L)-Basal	6.70 ± 0.65
TLC (L)-Post treatment	6.40 ± 0.60
Clinical function	
6MRD (M)-Basal	300.13 ± 42.51
6MRD (M)-Post treatment	402.88 ± 40.13
CAT-Basal	22.00 ± 5.31
CAT-Post treatment	12.75 ± 4.71
MMRC-Basal	2.00 ± 0.82
MMRC-Post treatment	0.75 ± 0.75

transient fever (3/8, 37.5%), cough (6/8, 75%), and mild inflammatory changes on chest CT (2/8, 25%). All events were self-limited or managed conservatively, without the need for invasive intervention or prolonged hospitalization. A summary of these events is presented in Table 1. The longitudinal assessment of pulmonary function, including FEV_1, FVC, and the FEV_1/FVC ratio (Figure 1), revealed significant improvements as early as 1 month following Bronchoscopic Thermal Vapor Ablation (BTVA). These improvements were sustained at 6 months, with a notable increase in FEV_1 and FVC at 1 month post-treatment. Although the FEV_1/FVC ratio showed a mild increase at 1 and 3 months, statistical significance was only reached at 6 months (Figure 1). Regarding lung hyperinflation, all patients showed a decrease in residual volume (RV) and total lung capacity (TLC) after BTVA. The mean RV decreased from 4.00 ± 0.55 L at baseline to 3.45 ± 0.50 L after treatment, while TLC decreased from 6.70 ± 0.65 L to 6.40 ± 0.60 L, indicating reductions of approximately 14% and 5%, respectively. These findings suggest effective reduction of lung hyperinflation consistent with the improvement in FEV_1, FVC, and exercise tolerance (Table 1).

In terms of clinical function, the 6-minute walk distance (6MWD) showed significant improvement at 1 month, with sustained gains through 6 months post-treatment (Figure 2A). Similarly, the COPD Assessment Test (CAT) scores demonstrated a marked reduction in symptom severity, with significant improvements noted at 1 month and continuing through the 6-month follow-up (Figure 2B). Additionally, the Modified Medical Research Council (mMRC) dyspnea scale indicated a reduction in breathlessness, with improvements seen as early as 1 month and maintained over the 6-month period (Figure 2C).

Chest CT scans performed at the 6-month follow-up showed a significant reduction in the volume of the targeted lung segments (Figure 3A). The pre-treatment volume of 707.5 ± 115.74 mL decreased to 335.5 ± 129.59 mL at 6 months (Figure 3B), indicating a substantial reduction in hyperinflation and a favorable therapeutic response. These findings support the efficacy of BTVA in improving both pulmonary function and clinical outcomes in patients with advanced COPD.

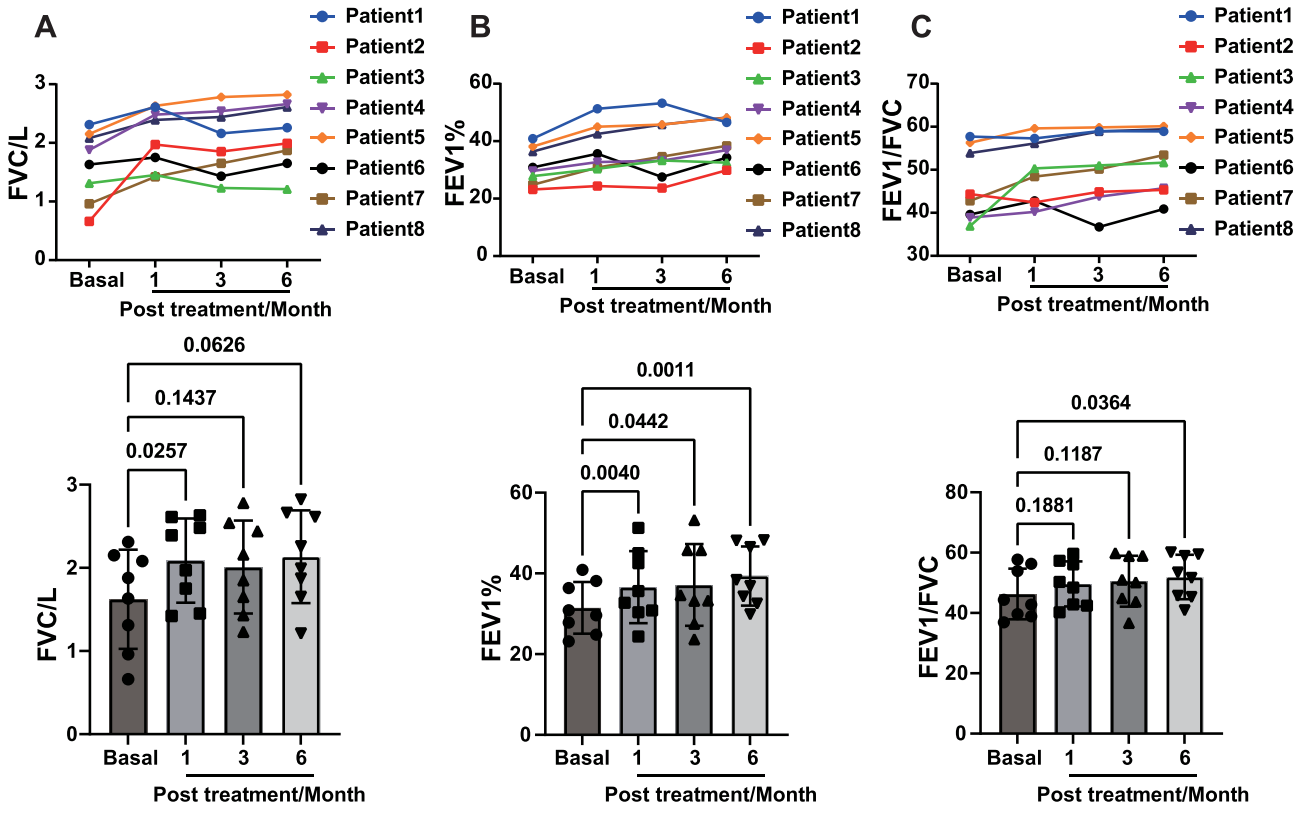

Figure 1 Changes in pulmonary function parameters after Bronchoscopic Thermal Vapor Ablation (BTVA) in COPD patients. (**A**) Forced Vital Capacity (FVC) over 6 months post-treatment. (**B**) Forced Expiratory Volume in 1 second (FEV_1) over 6 months post-treatment. (**C**) The ratio of FEV_1 to FVC (FEV_1/FVC) over 6 months post-treatment. Each graph represents the individual changes in pulmonary function parameters for each patient. Data are presented as mean ± standard deviation. Statistical comparisons between baseline and post-treatment months (1, 3, and 6) were performed using one-way anova. Significant differences are indicated by the p-values above the bars, with $p < 0.05$ considered statistically significant.

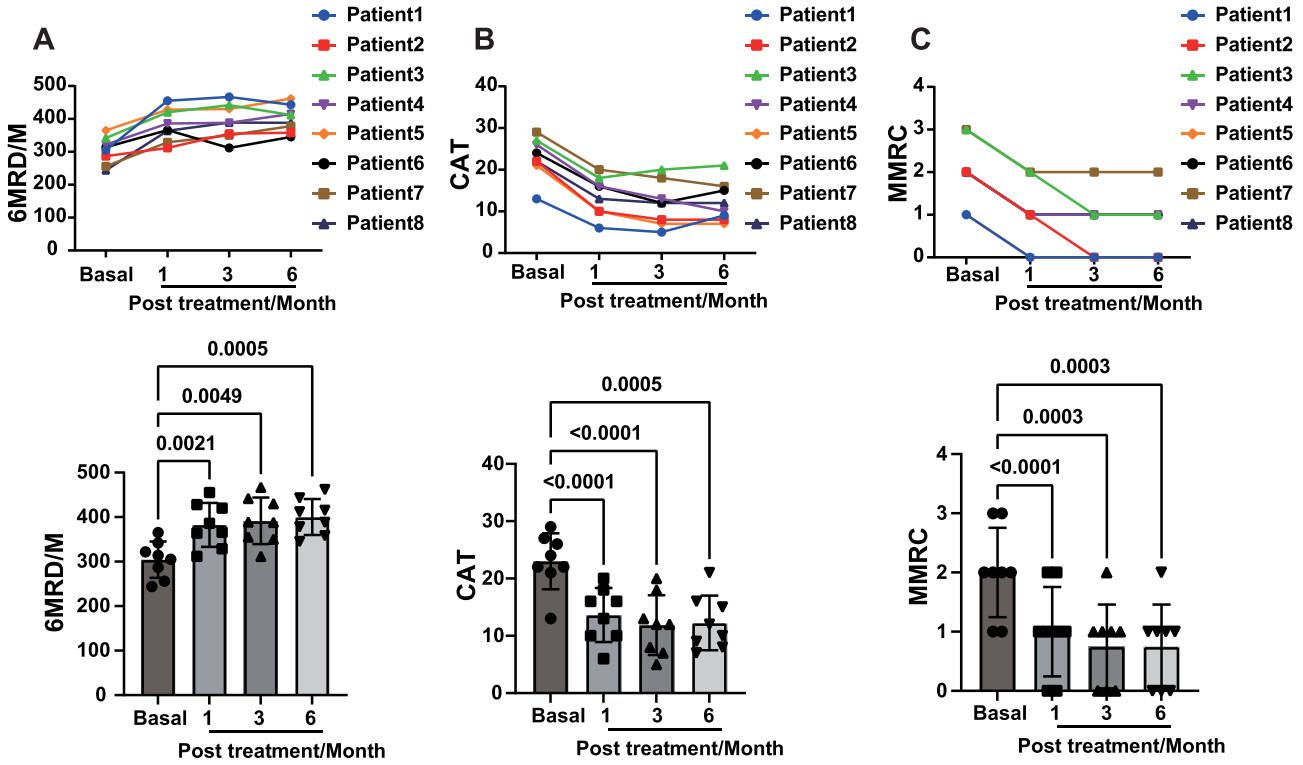

Figure 2 Changes in exercise capacity and dyspnea scores after Bronchoscopic Thermal Vapor Ablation (BTVA) in COPD patients. (**A**) 6-minute walk distance (6MWD) over 6 months post-treatment. (**B**) COPD Assessment Test (CAT) scores over 6 months post-treatment. (**C**) Modified Medical Research Council (mMRC) dyspnea scale over 6 months post-treatment. Each graph shows the individual changes for each patient. Data are presented as mean ± standard deviation. Data are presented as mean ± standard deviation. Statistical comparisons between baseline and post-treatment months (1, 3, and 6) were performed using one-way anova. Significant differences are indicated by the p-values above the bars, with $p < 0.05$ considered statistically significant.

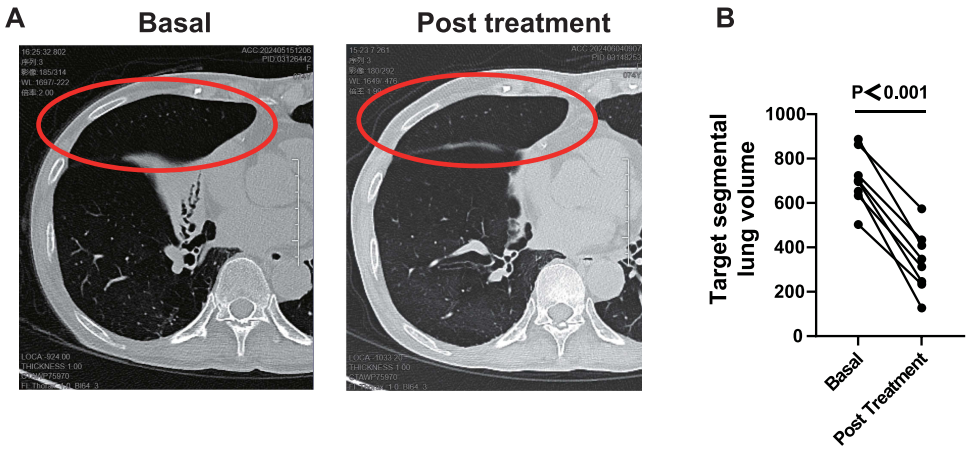

Figure 3 CT imaging and target segmental lung volume changes following Bronchoscopic Thermal Vapor Ablation (BTVA) in COPD patients. (**A**) Representative axial CT images showing the target segment before (left) and after (right) BTVA treatment. The target segment is highlighted by the red circle. (**B**) Change in target segmental lung volume between baseline and post-treatment. Data are presented as individual patient changes, and statistical comparison was performed using paired *t*-test.

Discussion

The preliminary findings of this study suggest that Bronchoscopic Thermal Vapor Ablation (BTVA) can significantly improve pulmonary function and clinical outcomes in patients with COPD over the short term. Although the sample size was small (n = 8), marked improvements in key parameters such as FEV_1, FVC, and 6MWD were observed as early as one month post-procedure, with these improvements sustained through the 6-month follow-up period. Notably, FEV_1

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/FVC showed only a mild and statistically non-significant increase at 1 and 3 months, but reached a significant level by month 6, suggesting a delayed yet meaningful response. Additionally, chest CT imaging demonstrated a substantial reduction in the volume of targeted lung segments—from 707.5 ± 115.74 mL pre-treatment to 335.5 ± 129.59 mL at 6 months post-BTVA—confirming a structural reduction in hyperinflated lung tissue.

These results are consistent with real-world data on BTVA,[15] which typically show maximal benefit between 6 and 12 months post-treatment, followed by a gradual decline over time. This pattern of initial improvement followed by functional decline mirrors that observed with other bronchoscopic lung volume reduction (BLVR) techniques, such as endobronchial coils and valves.[16] The progressive nature of COPD likely accounts for this trend, as BLVR does not alter the disease course but provides temporary relief by reducing hyperinflation and allowing healthier lung tissue to expand. Even though functional gains may wane over time, achieving initial improvement—when compared to the steady decline observed in untreated patients—remains a clinically meaningful outcome.

One potential advantage of BTVA lies in its simplicity and repeatability. The procedure allows for precise targeting of the most affected subsegments and can be repeated in different lung regions if clinical deterioration occurs. This repeatability may help prolong functional improvement in selected patients. Although our current study did not include patients who underwent sequential BTVA procedures, previous reports and clinical experience suggest that repeated treatment can be beneficial in certain cases. However, this approach has not yet been validated in prospective trials, and further research is needed to determine whether sequential interventions provide sustained benefits beyond the initial treatment.

From a practical standpoint, BTVA offers a minimally invasive lung volume reduction option suitable for patients who are poor surgical candidates. However, safety remains an important consideration: pneumonia, COPD exacerbation, and procedure-related complications have been reported in both randomized and real-world studies.[17] Careful patient selection is therefore crucial, with particular attention to emphysema distribution, hyperinflation severity, and comorbidities.[15] In addition, while the procedure can be repeated in staged or contralateral segments, the long-term durability of sequential treatments remains uncertain and requires confirmation in prospective trials. Future research should focus on refining selection criteria, monitoring long-term efficacy, and evaluating combination strategies with pharmacologic therapy or pulmonary rehabilitation to optimize sustained benefits.[13]

Our study has several limitations. First, its retrospective design may introduce information bias, and some patients were excluded from repeated measures analysis due to incomplete data across time points. Second, the absence of a control group limits our ability to conclusively attribute improvements to BTVA. Nonetheless, the significant changes observed in paired analyses compared to baseline suggest a true therapeutic effect. Third, the sample size was relatively small (n = 8), although it is comparable to other early-stage studies in this field. Lastly, the follow-up duration was limited to 6 months, and long-term outcomes remain to be fully characterized.

Conclusion

In conclusion, BTVA appears to be a promising and minimally invasive bronchoscopic intervention for lung volume reduction in patients with advanced COPD. In this retrospective analysis of 8 patients, significant improvements in pulmonary function were observed at 1 to 6 months post-treatment, alongside notable reductions in targeted lung volume. Although long-term efficacy and the potential role of repeat treatment remain to be determined, these findings support the use of BTVA as an effective short-term therapeutic strategy. Future prospective, controlled studies are warranted to refine patient selection, enhance safety, and assess long-term clinical outcomes.

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Disclosure

The authors declare that they have no conflicts of interest related to this work.

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