

Temporary Right Middle Lobe Occlusion with a Blocking Device to Enable Collateral Ventilation Measurement of the Right Major Fissure

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Established Facts

- Chartis measurement of the lower lobes can be hampered by a “no-flow” phenomenon, preventing a reliable measurement of interlobar collateral ventilation.
- In the left lung, this can easily be resolved by performing measurement of the left major fissure in the left upper lobe.
- Measurement of the right major fissure in the right upper lobe is not directly possible because of the presence of the right middle lobe.

Novel Insights

- Temporary occlusion of the right middle lobe will facilitate a reliable Chartis measurement of the right major fissure in the right upper lobe.
- This occlusion can easily be performed using either a Watanabe spigot or a balloon catheter.

Keywords

Chartis measurement · No-flow phenomenon · Right middle lobe occlusion

Abstract

Background: Absence of interlobar collateral ventilation is essential to achieve lobar volume reduction after endobronchial valve (EBV) treatment and can be assessed using the Chartis measurement. However, especially in lower lobe measurements, Chartis can be complicated by the “no-flow

phenomenon”, during which a sudden cessation of flow is observed, leading to an unreliable measurement. If this phenomenon occurs in the right lower lobe, when measuring collateral flow over the right major fissure, the entrance to the right middle lobe should be occluded, and the Chartis balloon should be placed in the right upper lobe. Both Watanabe spigots and balloon catheters can be used to achieve occlusion. **Objective:** Our aim was to demonstrate that right middle lobe occlusion with a blocking device is helpful in obtaining a reliable Chartis outcome in case of the no-flow phenomenon in the right lower lobe. **Methods:** We per-

formed a retrospective analysis of patients scheduled for EBV treatment in an EBV registry between September 2016 and September 2019. **Results:** We included 15 patients with severe emphysema (median age 63 years [range 47–73], 73% female, and FEV₁ 24% [range 19–36] of predicted), who required temporary middle lobe occlusion (12 Watanabe spigot, 3 balloon catheter). After occlusion, a reliable Chartis outcome was obtained in all patients. **Conclusion:** Temporary middle lobe occlusion using a blocking device is helpful in obtaining a reliable Chartis outcome in case of a right lower lobe no-flow phenomenon.

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Introduction

The absence of interlobar collateral ventilation is essential to achieve lobar volume reduction with endobronchial valve (EBV) treatment in patients with severe emphysema and can be assessed using the Chartis® (Pulmonx, USA) measurement [1–4]. Chartis measurement can be complicated by the “no-flow phenomenon”, in which dynamic expiratory airway collapse is believed to cause a sudden cessation of flow during measurement, leading to an unreliable Chartis measurement [5]. Literature shows that this can occur in up to one-third of all measurements and most frequently affects the lower lobes [5–7]. Normally, Chartis measurement is performed in the lobe selected for treatment with EBV. When the no-flow phenomenon occurs during measurement in the left lung, measurement in the adjacent lobe can easily be performed to assess the integrity of the left major fissure [8]. However, in case of no flow in the right lower lobe, measurement of the right upper lobe may not be reliable because collateral flow originating from the right middle

lobe, due to common incompleteness of the right minor fissure, can result in false-positive Chartis outcomes [1]. If the middle lobe is not occluded, the measurement in the right upper lobe only measures the collateral flow over the right upper lobe fissure (part of the major fissure and minor fissure) and not the right major fissure.

Case Report

Methods

We performed a retrospective analysis in which we included all patients with the right lower lobe as primary EBV target and in which the no-flow phenomenon occurred during Chartis measurement in the right lower lobe.

All patients were scheduled for treatment in the Dutch national EBV treatment registry (BREATH-NL) between September 2016 and September 2019 (Clinicaltrials.gov identifier: NCT02815683). Chartis measurements were performed in all patients regardless of fissure integrity scores. The presence of collateral ventilation was confirmed when a continuous, non-decreasing, expiratory airway flow was observed during >6 min or earlier with a similar pattern when totaling >1 L [8]. Every patient underwent Chartis measurement under general anesthesia using a previously described approach [9]. Target lobe volume and fissure integrity were assessed using the StratX quantitative CT Platform (Pulmonx).

To achieve the desired temporary occlusion of the right middle lobe, both Watanabe spigots® (Novatech, France) and Extractor® Pro retrieval balloon catheters (Boston Scientific, USA), were used. The Watanabe spigot (Fig. 1) is a silicon bronchial filler, which is frequently used for persistent pneumothorax, hemoptysis, and bronchopleural fistula, and is available in three sizes: 5, 6 and 7 mm in diameter [10]. The retrieval balloon (Fig. 2) can be inflated to any desired diameter between 5 and 20 mm and can be replaced by any locally available alternative balloon.

Our primary outcome was the success rate of right upper lobe Chartis measurement of the right major fissure after occlusion of the right middle lobe and placement of the Chartis balloon in the right upper lobe. Our secondary outcome was the amount of target lobe volume reduction after EBV treatment.

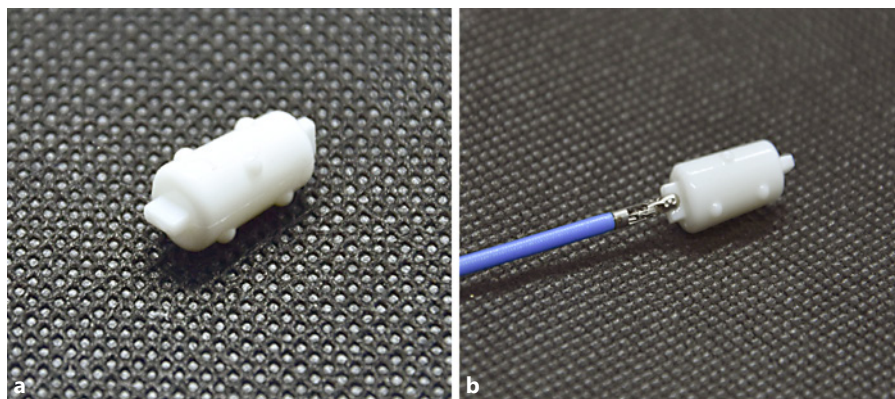


Fig. 1. **a** Watanabe spigot. **b** Watanabe spigot held by a biopsy forceps, which can be used for both placement and removal of the spigot.

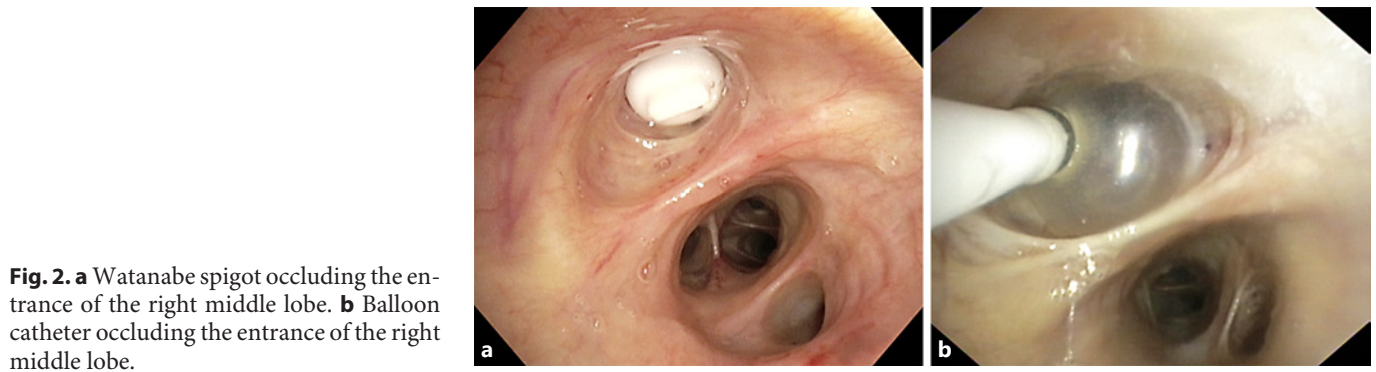


Fig. 2. a Watanabe spigot occluding the entrance of the right middle lobe. **b** Balloon catheter occluding the entrance of the right middle lobe.

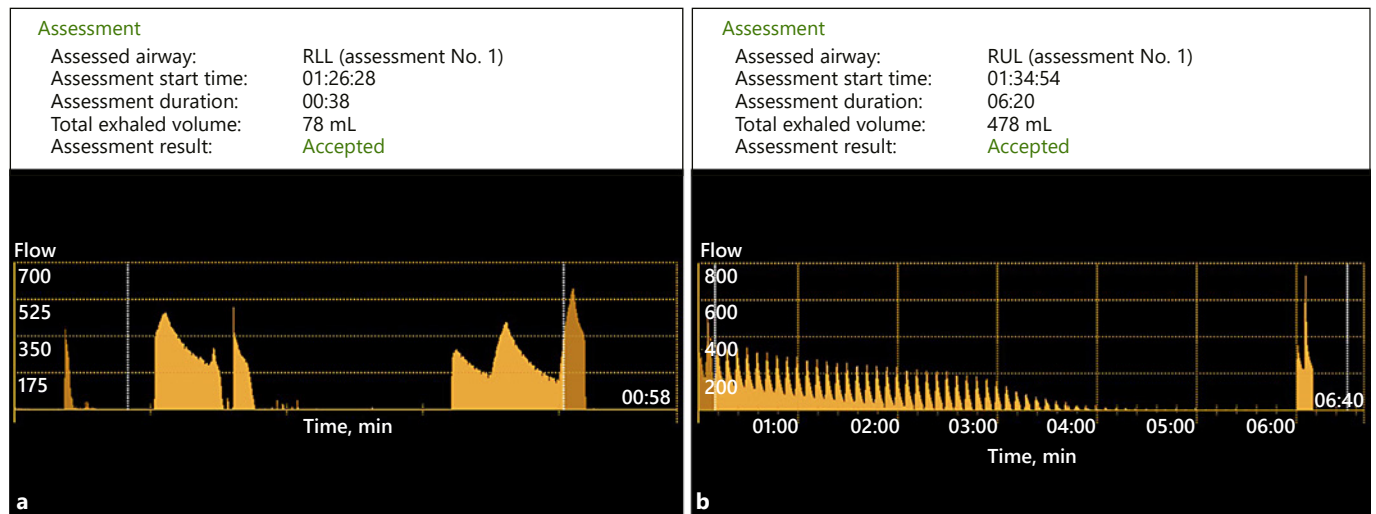


Fig. 3. a Chartis measurement output indicating the no-flow phenomenon in the right lower lobe. The initially present flow becomes zero after the balloon seal is achieved, flow returns when the catheter is withdrawn with subsequent loss of the balloon seal, ruling out other potential causes of no flow. **b** Chartis measurement output of the right upper lobe in the same patient, indicating absence of interlobar collateral ventilation after occlusion of the right middle lobe with a Watanabe spigot.

ing out other potential causes of no flow. **b** Chartis measurement output of the right upper lobe in the same patient, indicating absence of interlobar collateral ventilation after occlusion of the right middle lobe with a Watanabe spigot.

Table 1. Patient characteristics

| | |
|-------------------------------|------------------|
| Patients, <i>n</i> | 15 |
| Female/male, % | 73/27 |
| Age, years | 63 (47–73) |
| BMI | 22 (19–30) |
| Pack years | 43 (10–85) |
| FEV ₁ predicted, % | 24 (19–36) |
| RV predicted, % | 229 (187–317) |
| RV/TLC, ratio | 0.65 (0.58–0.76) |
| 6MWD, m | 320 (15–484) |

Data are presented as median (range), unless otherwise indicated. BMI, body mass index; FEV₁, forced expiratory volume in 1 s; RV, residual volume; TLC, total lung capacity; 6MWD, 6-min walking distance.

Case Report

A 63-year-old female with severe emphysema (forced expiratory volume in 1 s [FEV₁] 25% of predicted and residual volume [RV] 214% of predicted) was scheduled for EBV treatment in our hospital. The predetermined target for treatment was the right lower lobe (51% of voxels <−950 Hounsfield Units). We were initially unable to obtain a reliable Chartis measurement in the right lower lobe, as we encountered the no-flow phenomenon (Fig. 3a). After the occlusion of the right middle lobe with a Watanabe spigot, we performed a Chartis measurement in the right upper lobe, which indicated absence of interlobar collateral ventilation of the right major fissure (Fig. 3b). Subsequently, five endobronchial valves were placed in the right lower lobe. Six weeks after treatment, the patient achieved a target lobe volume reduction of 1,201 mL, had an FEV₁ of 40% of predicted (69% relative increase), and an RV of 148% of predicted (31% relative reduction).

Table 2. Chartis measurement outcomes

| | |
|---|------------------------|
| Total EBV cases, <i>n</i> | 220 |
| Cases with RLL as primary EBV target, <i>n</i> | 36 |
| Cases where temporary RML occlusion was indicated, <i>n</i> (%) | 15 (42) |
| Blocking device used | |
| Watanabe spigot, <i>n</i> | 12 |
| Balloon catheter, <i>n</i> | 3 |
| Chartis measurement outcome right major fissure (CV negative/CV positive), <i>n</i> | 13/2 |
| Target lobe volume at baseline, mL | 1,625 (1,027 to 3,001) |
| Target lobe volume reduction at 6 weeks after treatment, mL | -863 (-3,001 to 5) |
| Right major fissure integrity, % | 99 (95 to 100) |
| Right minor fissure integrity, % | 91 (58 to 98) |

Data are presented as median (range), unless otherwise indicated. RLL, right lower lobe; RML, right middle lobe; EBV, endobronchial valve; CV, collateral ventilation.

Case Series

Out of the 220 EBV cases, 36 patients (16%) had the right lower lobe as primary target for EBV. In 15 out of these 36 cases (42%), we performed a temporary right middle lobe occlusion with either a Watanabe spigot or balloon catheter in order to perform Chartis measurement of the right major fissure.

Therefore, 15 patients were included in the analysis (73% female, median FEV₁ 24% of predicted) (baseline characteristics are presented in Table 1). Temporary right middle lobe occlusion was successful in all patients. The Watanabe spigot was used in 12 cases. In 3 cases, the balloon catheter was used because the use of the Watanabe spigot was not possible because of a relatively large diameter entrance to the right middle lobe.

In all patients a reliable Chartis measurement could be performed after we placed the blocking device, and we did not observe a no-flow phenomenon. In 13 out of 15 patients (87%), the Chartis measurement in the right upper lobe indicated absence of collateral ventilation of the right major fissure. Six weeks after treatment, the median reduction in the target lobe volume was 863 mL, and 9 out of 13 patients (69%) had achieved the minimal important difference for target lobe volume reduction of 563 mL [11]. See Table 2 for Chartis measurement outcomes.

Discussion

This case series provides insight in the use of two different approaches to temporary right middle lobe occlusion, Watanabe spigots and balloon catheters, to achieve reliable Chartis measurement outcomes. Using this technique, we were able to confirm the presence or absence of interlobar collateral ventilation of the right major fissure in all our patients after initial measurement of the right lower lobe had failed. We considered both the insertion and removal of the Watanabe spigot and balloon catheter very feasible (see www.karger.com/doi/10.1159/000507401 for online suppl. video). While not structurally assessed in this case series,

use of the blocking devices did not prolong Chartis measurement for more than several minutes. Although both blocking device approaches were feasible, in our practice, we generally reserve the use of a balloon catheter for patients with a relatively wide right middle lobe entrance, given its larger potential diameter (5–20 mm) than the Watanabe spigot (5–7 mm).

While temporary right middle lobe occlusion was already recommended by the 2017 expert panel recommendations on EBV treatment, to the best of our knowledge, no data has previously been published on this technique [8].

Before the absence of flow during Chartis measurement is attributed to the no-flow phenomenon, we recommend excluding other causes of absent flow: mucus impaction of the Chartis catheter should first be ruled out by flushing of the catheter, and in addition, correct catheter positioning should be verified. The catheter tip should not be in direct contact with the airway wall. While different terminology is used in the literature to describe the no-flow phenomenon, for example “low flow” and “collapse phenomenon”, we suggest describing this problem as the no-flow phenomenon, as this description describes the clinical observation during measurement [5, 7].

Previous studies have attributed the no-flow phenomenon to dynamic expiratory airway collapse, in which airway collapse distal to the inflated Chartis balloon prevents expiratory airflow [5, 7]. While we consider this to be a valid explanation, the question remains why the lower lobes are more often affected by this phenomenon. A possible explanation may be the transpulmonary pressure gradient from the apical zones to the basal zones in combination with the emphysematous lung tissue. More research is required to confirm the exact physiological mechanism causing this phenomenon and its lower-lobe predominance.

In conclusion, selective temporary occlusion of the right middle lobe using a blocking device is helpful in obtaining a reliable Chartis outcome in case of the no-flow phenomenon in the right lower lobe. The application of this simple technique may improve patient selection and outcomes for EBV treatment.

Acknowledgements

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Statement of Ethics

According to the ethics committee of our hospital, this study did not fall within the scope of the WMO (Dutch Medical Research with Human Subjects Law), and therefore formal ethical approval was not needed. All patients provided written informed consent.

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Disclosure Statement

D.-J.S. is an investigator of and advisor to Pulmonx Inc., Redwood City, CA, USA. All other authors have no conflicts of interest to declare.

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Author Contributions

J.B.A.W. and D.-J.S. undertook conception and design of the study. T.D.K., M.v.D., K.K., and D.-J.S. performed the Chartis measurements and treatments. J.B.A.W., J.E.H., H.A.M.K., and D.-J.S. performed analysis and interpretation. All authors have read, improved, and approved the final version of the manuscript.