

Comparing the Carbon Footprint of Two Spontaneous Breathing Trial Strategies

Thomas Frapard^{*1,2}, *Marie Lecronier*^{* 3}, Aude Ruttimann⁴, Davuth Tan⁵, Alexandre Demoule³, Guillaume Carteaux^{1,2} and REAGIR study group

¹ Assistance Publique - Hôpitaux de Paris, Hôpitaux Universitaires Henri Mondor, DHU ATVB, Service de Réanimation médicale, 94000 Créteil, France

² Université Paris Est Créteil, Faculté de Médecine de Créteil, Institut Mondor de Recherche Biomédicale – Groupe de ; recherche clinique CARMAS, 94000 Créteil, France

³ Service de Médecine Intensive et Réanimation, AP-HP, Groupe Hospitalier Universitaire APHP-Sorbonne Université, Site Pitié-Salpêtrière, Paris, France

⁴Service de médecine intensive-réanimation, Hôpital Cochin, Assistance Publique - Hôpitaux de Paris, Paris, France.

⁵ Direction de la Stratégie et de la Transformation, AP-HP, Paris, France

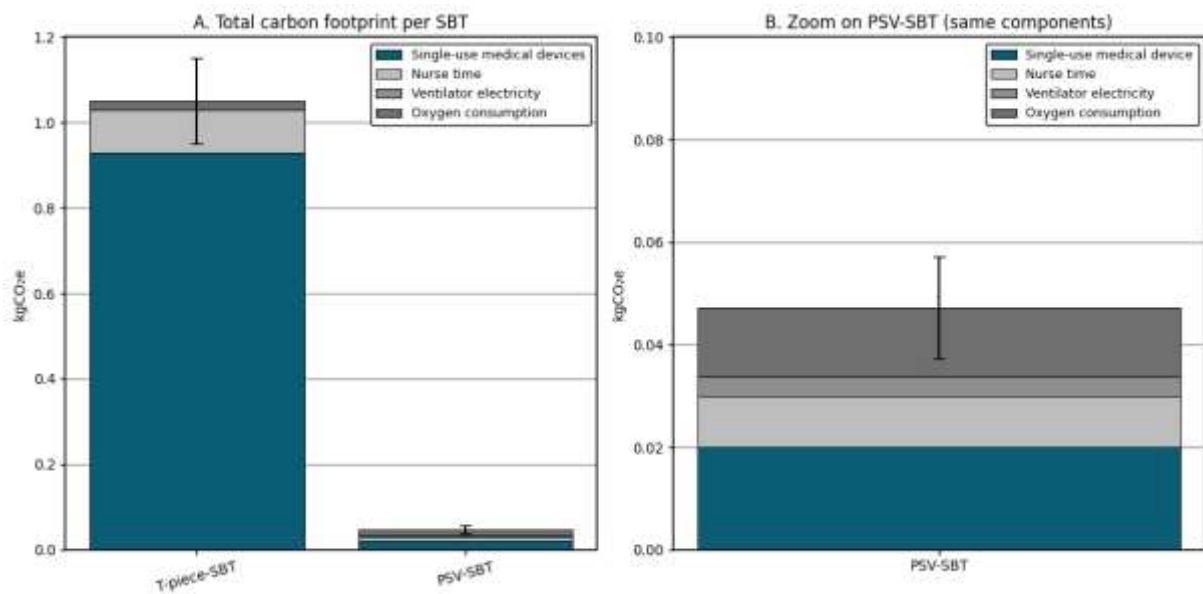
SUPPLEMENTARY MATERIAL

-Excel calculator

-Carbon methodology guide

Figure S1: Total carbon footprint per SBT

1. In France with low carbon electricity mix



2. In Australia with high carbon electricity mix

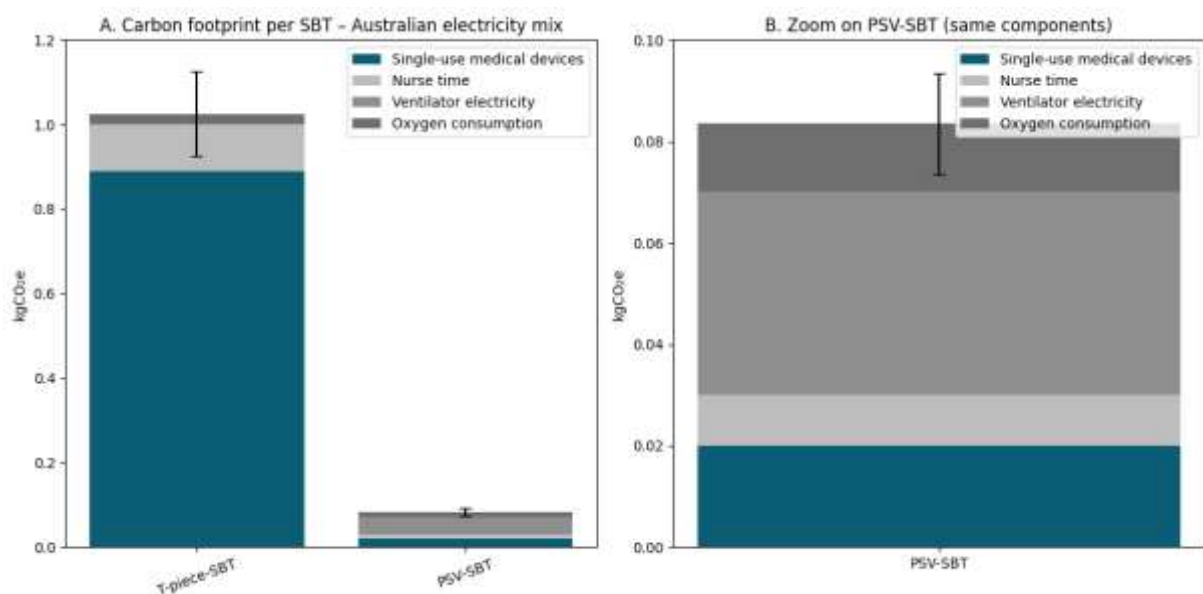


Figure S2: Oxygen consumption across various setting

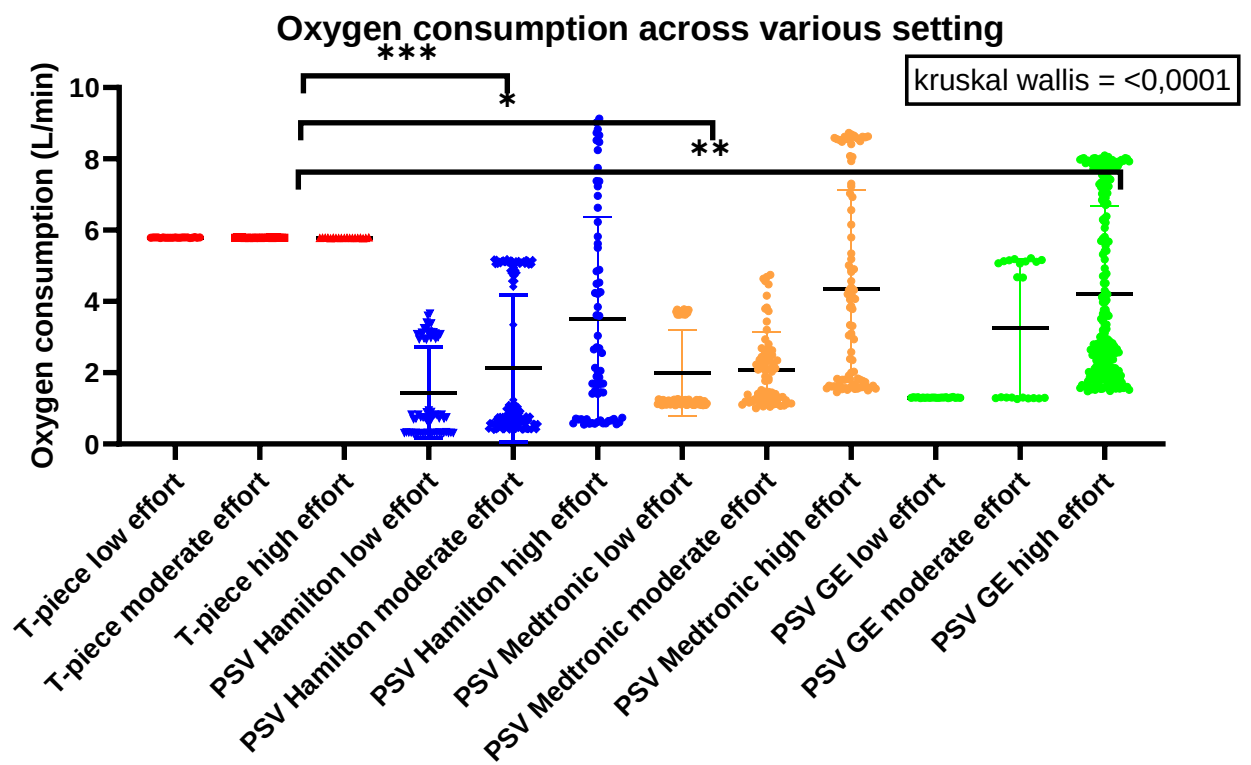


Table S1: Respiratory mechanics and target tidal volumes used for the bench simulations
(derived from Cabello et al. ICM 2010)

Condition	Compliance (mL/cmH ₂ O)	Resistance (cmH ₂ O·s/L)	Respiratory rate (breaths/min)	Target VT (mL)	Notes
PSV – Q1	40	10	16	273	Inspiratory effort adjusted to reach target VT; <i>Ti</i> ≈ 800 ms
PSV – Median	40	10	22	328	Inspiratory effort adjusted; <i>Ti</i> ≈ 800 ms
PSV – Q3	40	10	34	478	Inspiratory effort adjusted; <i>Ti</i> ≈ 800 ms
T-piece – Q1	40	10	21	254	Inspiratory effort adjusted to reach target VT
T-piece – Median	40	10	27	325	Inspiratory effort adjusted
T-piece – Q3	40	10	35	443	Inspiratory effort adjusted

Additional settings:

- **PSV-SBTs:** FiO₂ 40%, no PEEP, pressure support level 8 cmH₂O.
- **T-piece-SBTs:** oxygen flow at 6 L/min.
- For all conditions, inspiratory effort was tuned on the ASL5000 to reproduce the tidal volumes reported for the first quartile (Q1), median, and third quartile (Q3) in Cabello et al.
- Inspiratory time (*Ti* ≈ 800 ms) was standardized for all ZEEP conditions.

Table S2: **SBT number in the WEAN SAFE cohort (n=5869)**

Patients	Median	Q1	Q3	Min	Max
Short wean (n=2927)	1	0	1	0	29
Intermediate wean (n=457)	2	0	3	0	7
Prolonged wean (n=433)	1	0	3	0	24
Died before weaning success (n=553)	1	0	1	0	14
Transferred before weaning success (n=153)	1	0	2	0	10
No separation attempt (n=1346)	0	0	0	0	0

Table S3 : Contribution of individual life-cycle components to the carbon footprint of one spontaneous breathing trial

Emission source	PSV-SBT (kgCO ₂ e)	T-piece-SBT (kgCO ₂ e)
Oxygen consumption	0.0099*	0.0226
Medical compressed air	0.0036	0.0000
Ventilator electricity consumption	0.0037†	0.0000
Nursing activities‡	0.0179	0.1250
Hand hygiene	0.0100	0.0100
Disposable medical devices	0.0000	0.873-0.905§
Total carbon footprint per SBT	0.0451**	1.04-1.07

* Average of low-, moderate-, and high-effort breathing simulations (94, 116 and 248 L O₂·h⁻¹).

† Average of the three ventilators tested (Hamilton C6, PB980 Medtronic and GE Carescape R860) considering French electricity mix (0,0407 kgCO₂ considering Australian electricity mix)

‡ Estimated from healthcare worker transportation associated with SBT implementation.

§ Depending on the use of a cuff manometer (0.873 kgCO₂e) or a sterile syringe (0.905 kgCO₂e) for cuff pressure management.

**Considering French electricity mix (0,0820 kgCO₂ considering Australian electricity mix)

Table S4: Disposable medical devices included in the T-piece-SBT scenario and associated cradle-to-grave emissions

Device	Quantity	Carbon footprint (kgCO ₂ e)
Oxygen tubing	1	0.108
Heat and moisture exchanger	1	0.095
Disposable polyethylene apron	2	0.258
Alcohol-based hand rub	2 doses	0.010
Non-sterile nitrile gloves	2 pairs	0.171
Cuff manometer	1	0.002
or sterile syringe (10 mL)	1	0.034
Sterile aspiration catheter	1	0.076
Sterile non-woven compresses	1 pack	0.126
Saline unit dose (5 mL)	1	0.027
Total disposable devices		0.873-0.905

Table S5: Material flow used for each SBT strategy

	Number of units used for one T-piece-SBT	Number of units used for one PSV-SBT
<i>Personal protective equipment</i>		
Protective apron	2	0
Pair of non-sterile gloves	2	0
<i>Sterile disposable device</i>		
10 ml syringe	1	0
Tracheo-bronchial suction catheter	1	0
Heat and moisture exchanger spontaneous breathing	1	0
<i>Non sterile disposable device</i>		
Oxygen tubing	1	0
Total weight (g)	110	0

Table S6. **Extrapolated carbon footprint of SBT strategies using published mechanically ventilated patient cohorts (Jivraj et al JAMA internal med 2023)**

Country	Mechanically ventilated patients	Assumed SBTs per patient	Estimated SBTs	100% T-piece-SBT (tCO ₂ e)	100% PSV-SBT (tCO ₂ e)	Avoided emissions (tCO ₂ e)
England	59,873	0.85	50,892	53.4	2.3	51.1
Canada	70,250	0.85	59,713	62.7	2.7	60.0
United States	1,614,768	0.85	1,372,553	1,441.2	61.9	1,379.3

*Estimated using **0.85 SBT per mechanically ventilated patient**, corresponding to the weighted median number of SBTs derived from the WEAN-SAFE study (Table S2). Carbon emissions were calculated using the mean cradle-to-grave carbon footprint measured in the present study (**1.05 kgCO₂e per T-piece-SBT** and **0.0451 kgCO₂e per PSV-SBT**, Table S4).*