Benefits of the Pulsatile Right Ventricle on Pulmonary Artery Extracorporeal Membrane Oxygenation in Piglets Model of Acute Respiratory Distress Syndrome

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DECLARATIONS

Declaration of Conflicting interests: No conflict of interest.

Ethical Approval: The Animal Care and Use Committee of the Okayama University of Science (Okayama, Japan) approved that the experimental animals (certificate number:2021-040) were handled in accordance with Federal Law and guidelines of the "Guide for the Care and Use of Laboratory Animals, Eighth Edition" prepared by the National Institutes of Health (NIH Publication, 2011).

Informed consent: Not applicable

Background

We investigated the impact of <u>right ventricle to pulmonary artery extracorporeal membrane oxygenation(**RV-PA ECMO**</u>) in acute respiratory dysfunction with or without **pulsatile flow**.
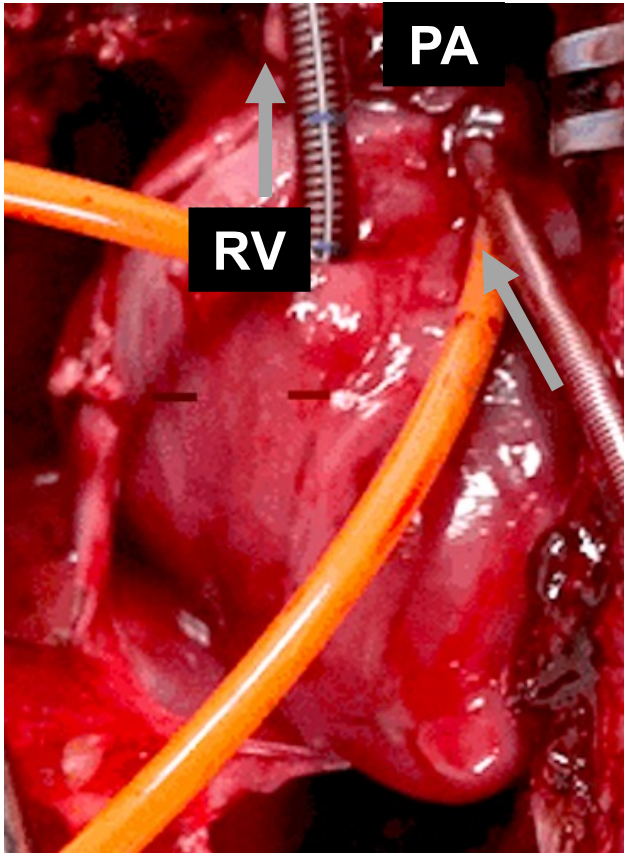
Methods

✓Bronchoalveolar lavage procedure with intrapulmonary administration of warm saline to establish a **severe acute respiratory syndrome model** (PaO$_2$/FiO$_2$ ratio < 200)

✓**8 piglets (mean body weight: 8.45±1.24 kg)**

✓**Pulsatille VS. Non-Pulsatile RV-PA ECMO**

Experimental Design
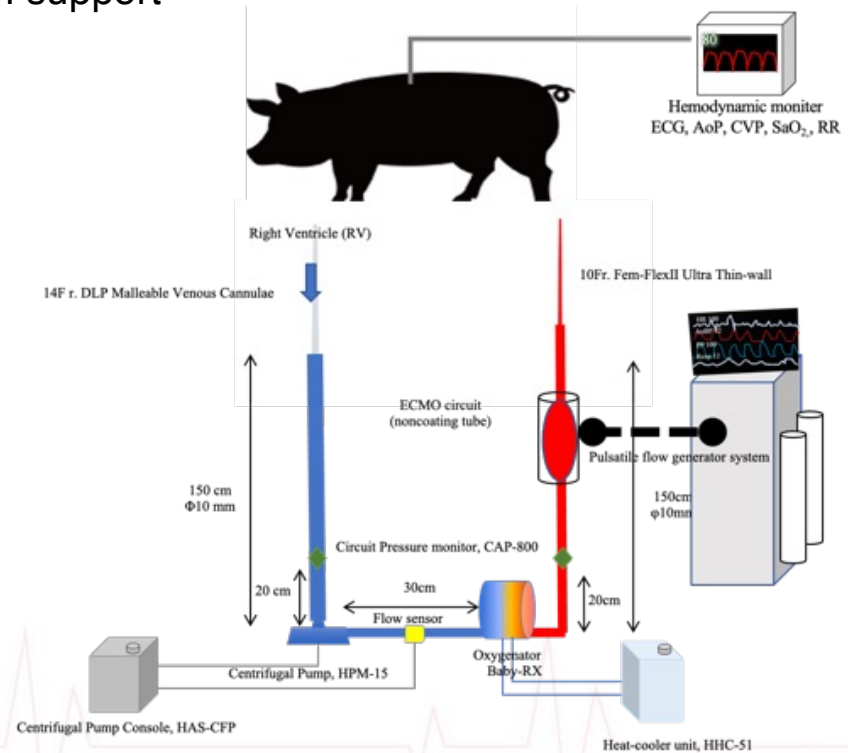
✓ We monitored **hemodynamic data** and **blood gas levels**

✓ **Cytokines IL-6** and **ET-1**

✓ **The lung wet/dry weight ratio**

✓ **Lung tissue samples for pathological evaluation of the pneumocyte**

RV—PA ECMO Circuit

- ✓ ECMO flow: 60mL/kg/min
- ✓ Activation clotting time (with heparin sodium): 180-200 s
- ✓ 6 h support

Statistical Analysis

✓ SPSS for MAC, Ver 28.0.1.1

✓ T-test and Mann-Whitney U test

✓ Statistical significance; P value <0.05

✓ Power analysis; sifinificance level of 0.05, power of 0.6

Time-dependent laboratory values during procedures in pulsatile and nonpulsatile groups

		After induction of anesthesia	After inductuion of ARDS model	After 1h ECMO	After 3h ECMO	After 6h ECMO
PH	P	7.64 ± 0.53	7.64 ± 0.53	7.24 ± 0.44	7.29 ± 0.27	7.18 ± 0.25
	NP	7.53 ± 0.11	7.37 ± 0.15	7.29 ± 0.02	7.20 ± 0.15	7.14 ± 0.19
PO2 (mmHg)	P	302.00 ± 33.21	60.25 ± 33.21	77.00 ± 8.45	57.75 ± 7.23	70.00 ± 5.57
	NP	308.50 ± 38.73	57.75 ± 12.66	70.25 ± 8.22	60.75 ± 12.50	61.00 ± 15.12
PCO2 (mmHg)	P	33.40 ± 3.11	37.53 ± 17.58	34.05 ± 18.50	27.28 ± 15.39	24.98 ± 10.73
	NP	32.70 ± 2.38	53.25 ± 15.18	47.18 ± 5.61	44.53 ± 8.91	44.25 ± 9.52
BE (mmol/L)	P	- 0.75 ± 5.97	2.00 ± 10.45	- 5.75 ± 3.30	- 6.00 ± 2.94	-7.25 ± 2.06
	NP	3.50 ± 1.29	4.25 ± 1.26	- 4.00 ± 1.83	- 7.00 ± 0.82	- 7.75 ± 1.71
HCO3- (mmol/L)	P	23.43 ± 4.93	24.15 ± 3.16	22.50 ± 4.47	20.05 ± 2.90	19.55 ± 3.28
	NP	33.05 ± 1.92	29.38 ± 1.03	21.65 ± 0.78	17.30 ± 1.34	20.68 ± 3.67
SaO2 (%)	P	99.25 ± 0.93	86.00 ± 7.26	92.25 ± 2.63	89.00 ± 3.37	90.50 ± 2.52
	NP	100.00 ± 0.00	90.25 ± 7.41	94.50 ± 0.58	89.00 ± 0.00	87.50 ± 4.65
Na (mmol/L)	P	141.75 ± 5.97	143.50 ± 4.36	144.75 ± 2.22	143.75 ± 2.22	145.75 ± 4.50
	NP	140.25 ± 0.96	142.25 ± 0.96	143.50 ± 1.73	145.25 ± 2.63	145.50 ± 2.65
K (mmol/L)	P	3.48 ± 1.75	3.50 ± 0.99	3.50 ± 1.31	3.65 ± 0.77	3.58 ± 0.96
	NP	4.05 ± 0.58	3.73 ± 0.22	3.65 ± 0.50	3.23 ± 0.95	3.25 ± 0.95
Ca (mmol/L)	P	1.32 ± 0.13	1.31 ± 0.04	1.28 ± 0.08	1.36 ± 0.07	1.27 ± 0.21
	NP	1.37 ± 0.07	1.32 ± 0.03	1.31 ± 0.04	1.33 ± 0.06	1.34 ± 0.08
Glu (mg/dL)	P	114.00 ± 55.54	115.25 ± 34.41	119.00 ± 42.39	134.00 ± 44.77	127.25 ± 45.46
	NP	117.5 ± 44.44	140.25 ± 15.97	153.50 ± 33.67	140.50 ± 29.94	133.75 ± 34.89
HCT (%)	P	27.75 ± 9.56	24.00 ± 2.16	21.25 ± 2.63	19.50 ± 2.65	17.50 ± 1.29
	NP	27.50 ± 5.57	23.75 ± 1.26	21.00 ± 0.82	19.75 ± 0.96	17.75 ± 2.50
Hb (g/dL)	P	9.13 ± 2.73	8.15 ± 0.74	7.40 ± 0.96	6.68 ± 1.13	5.88 ± 0.49
	NP	9.58 ± 2.30	8.00 ± 0.41	7.20 ± 0.22	6.93 ± 0.15	5.98 ± 0.87
P/F Ratio	P	302.00 ± 17.33	60.25 ± 12.45	366.67 ± 40.22	275.00 ± 34.42	316.67 ± 39.75
	NP	308.75 ± 33.54	57.75 ± 10.96	334.94 ± 33.90	288.92 ± 51.54	290.61 ± 62.36
IL-6 (pg/mL)	P	16.33 ± 5.72				21.64 ± 10.13
	NP	3.18 ± 1.47				283.73 ± 62.31*
ET-1 (pg/mL)	P	5.41 ± 1.66				9.83 ± 7.49
	NP	7.43 ± 0.70				16.29 ± 12.23

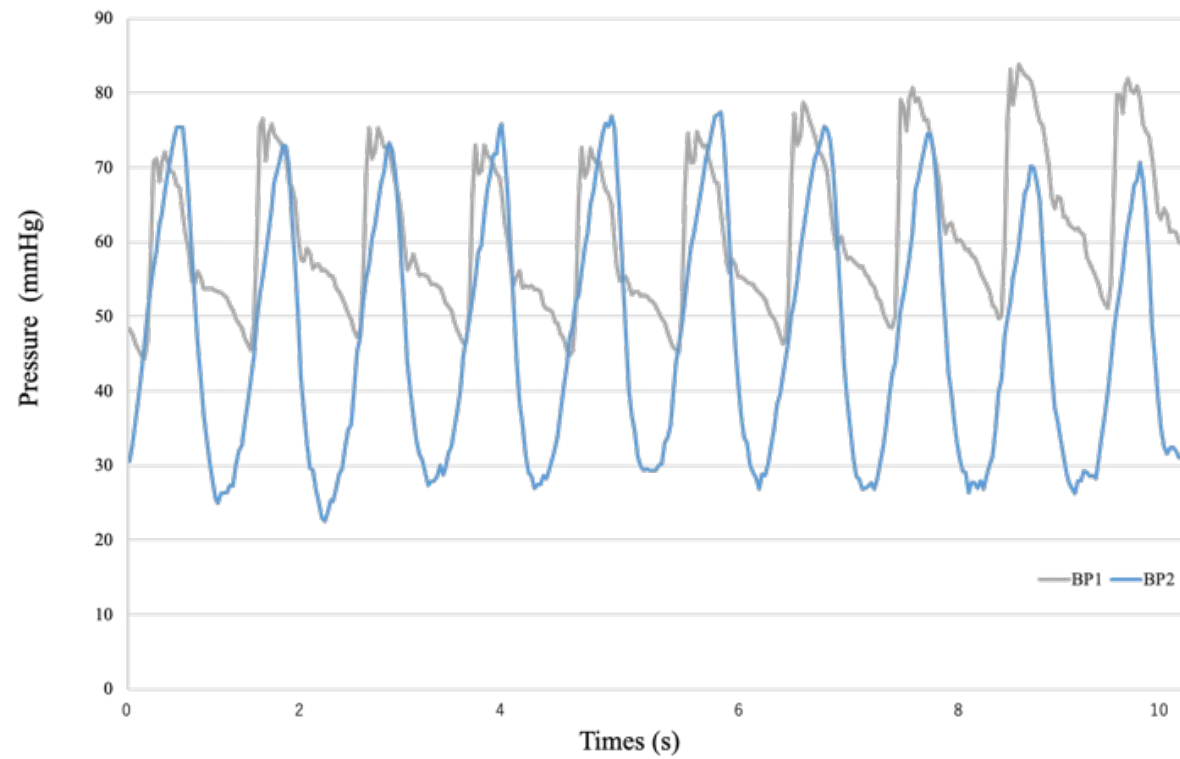# Time-dependent laboratory values during procedures in pulsatile and nonpulsatile groups

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PO2 (mmHg)	P	302.00 ± 33.21	60.25 ± 33.21	77.00 ± 8.45	57.75 ± 7.23	70.00 ± 5.57
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PCO2 (mmHg)	P	33.40 ± 3.11	37.53 ± 17.58	34.05 ± 18.50	27.28 ± 15.39	24.98 ± 10.73
	NP	32.70 ± 2.38	53.25 ± 15.18	47.18 ± 5.61	44.53 ± 8.91	44.25 ± 9.52
BE (mmol/L)	P	- 0.75 ± 5.97	2.00 ± 10.45	- 5.75 ± 3.30	- 6.00 ± 2.94	-7.25 ± 2.06
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	NP	100.00 ± 0.00	90.25 ± 7.41	94.50 ± 0.58	89.00 ± 0.00	87.50 ± 4.65
Na (mmol/L)	P	141.75 ± 5.97	143.50 ± 4.36	144.75 ± 2.22	143.75 ± 2.22	145.75 ± 4.50
	NP	140.25 ± 0.96	142.25 ± 0.96	143.50 ± 1.73	145.25 ± 2.63	145.50 ± 2.65
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	NP	4.05 ± 0.58	3.73 ± 0.22	3.65 ± 0.50	3.23 ± 0.95	3.25 ± 0.95
Ca (mmol/L)	P	1.32 ± 0.13	1.31 ± 0.04	1.28 ± 0.08	1.36 ± 0.07	1.27 ± 0.21
	NP	1.37 ± 0.07	1.32 ± 0.03	1.31 ± 0.04	1.33 ± 0.06	1.34 ± 0.08
Glu (mg/dL)	P	114.00 ± 55.54	115.25 ± 34.41	119.00 ± 42.39	134.00 ± 44.77	127.25 ± 45.46
	NP	117.5 ± 44.44	140.25 ± 15.97	153.50 ± 33.67	140.50 ± 29.94	133.75 ± 34.89
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	NP	27.50 ± 5.57	23.75 ± 1.26	21.00 ± 0.82	19.75 ± 0.96	17.75 ± 2.50
Hb (g/dL)	P	9.13 ± 2.73	8.15 ± 0.74	7.40 ± 0.96	6.68 ± 1.13	5.88 ± 0.49
	NP	9.58 ± 2.30	8.00 ± 0.41	7.20 ± 0.22	6.93 ± 0.15	5.98 ± 0.87
P/F Ratio	P	302.00 ± 17.33	60.25 ± 12.45	366.67 ± 40.22	275.00 ± 34.42	316.67 ± 39.75
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IL-6 (pg/mL)	P	16.33 ± 5.72				21.64 ± 10.13
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ET-1 (pg/mL)	P	5.41 ± 1.66				9.83 ± 7.49
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Hemodynamic pressure changes in pulsatile and non-pulsatile groups

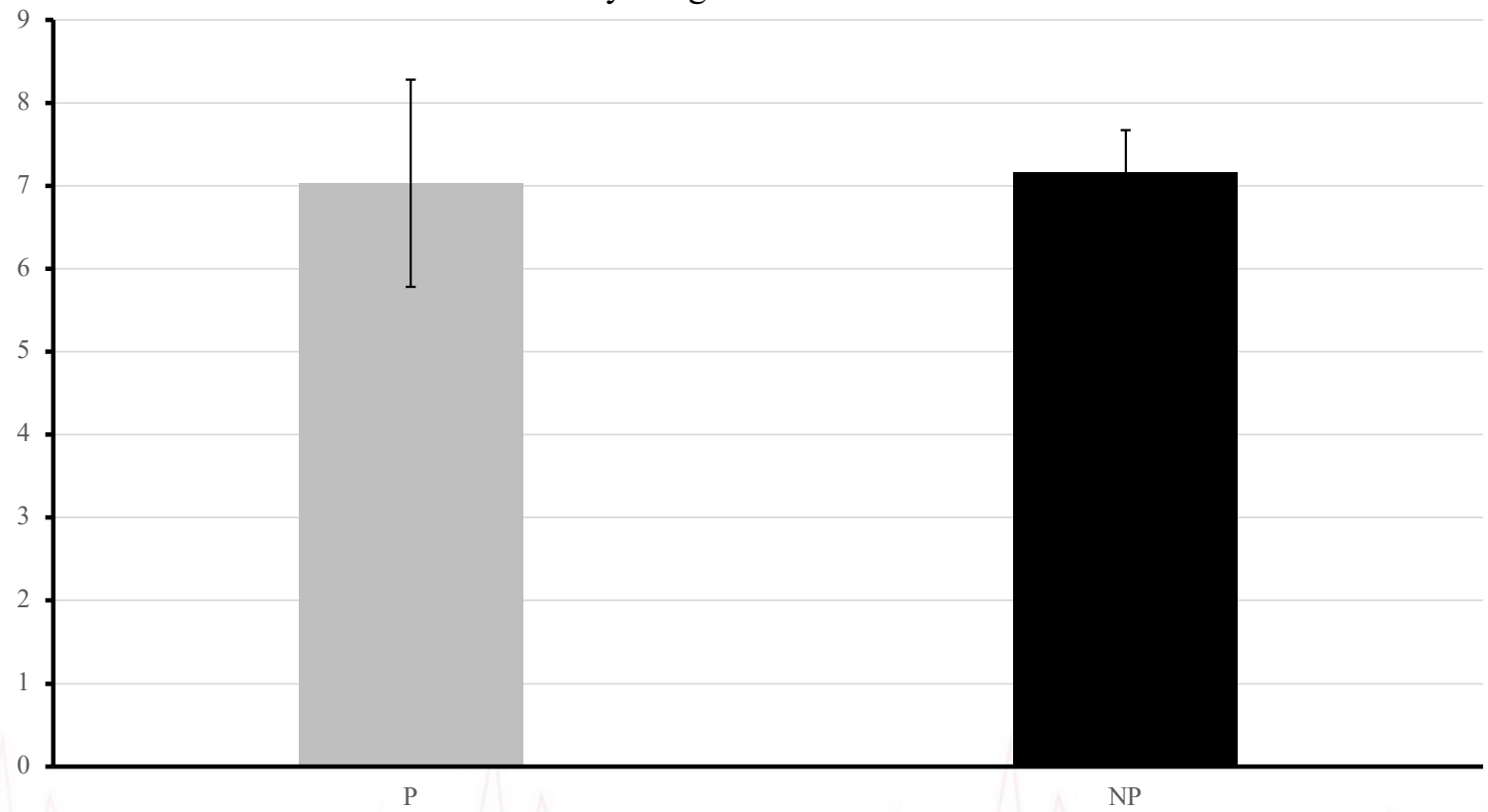|		After induction of anesthesia	After inductuion of ARDS model	After 1h ECMO	After 3h ECMO	After 6h ECMO
HR (BPM)	P	140.50 ± 17.40	125.25 ± 8.87	112.24 ± 14.88	109.75 ± 9.81	121.50 ± 14.37
	NP	123.00 ± 18.12	107.50 ± 21.65	130.00 ± 1.41	128.25 ± 10.91	128.50 ± 11.08
SBP (mmHg)	P	105.25 ± 22.35	104.00 ± 17.19	80.25 ± 5.89	82.25 ± 8.47	95.00 ± 5.61
	NP	120.00 ± 12.25	104.75 ± 6.98	75.25 ± 9.36	96.75 ± 13.8	92.75 ± 7.92
DBP (mmHg)	P	64.00 ± 15.92	63.50 ± 19.24	49.75 ± 5.67*	47.25 ± 9.52	56.00 ± 6.82
	NP	61.75 ± 7.69	75.00 ± 17.13	33.00 ± 2.24	48.25 ± 1.79	43.75 ± 9.18
MAP (mmol/L)	P	79.00 ± 16.90	76.50 ± 18.77	66.00 ± 5.24*	55.00 ± 5.85	72.00 ± 4.12
	NP	83.25 ± 9.58	84.50 ± 16.32	47.75 ± 2.77	64.00 ± 4.90	60.75 ± 8.58
MPAP (mmHg)	P		32.75 ± 3.11			10.7 ± 3.03*
	NP		31.25 ± 4.44			20.5 ± 3.64

Pulsatile Wave Form

Pathological evaluation of pneumocytes with a light microscope before and after non-pulsatile and pulsatile RV-PA ECMO

The lung wet/dry weight ratios

Wet / Dry Weight Ratios

Conclusions

- ➢ **RV-PA ECMO** can <u>prevent hypoxic pulmonary vasoconstriction and hypercapnia</u>.

- ➢ **RV-PA ECMO** improved symptoms of respiratory failure.

- ➢ **RV-PA ECMO** could lead to a <u>resting RV heart</u> and <u>improve RV functions and ARDS symptoms</u>.

- ➢ **Pulsatile RV-PA ECMO** led to <u>less inflammation and achieved better ventilation</u>.

- ➢ **Pulsatile RV-PA ECMO** may act to <u>depress ET-1 expression</u>.

Cám ơn vì sự quan tâm của bạn !