

CORRESPONDENCE



# Left ventricular overloading is the leading mechanism in extubation failure of patients at high-risk of weaning-induced pulmonary edema

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Dear Editor,

We read with interest the correspondence by Sanfilippo et al. [1] who suggest performing further analysis for our recently reported study [2]. As per their thoughtful suggestion, we first redefined the two study groups as “weaning success” ( $n=43$ ) when the patient could be extubated without reinstitution of ventilator support within 48 h after extubation, and as “weaning failure” ( $n=16$ ) whenever one the following occurred: (i) failed spontaneous breathing trial (SBT) ( $n=12$ ); (ii) reintubation and/or resumption of ventilator support within 48 h after extubation ( $n=3$ ); or (iii) death in the 48 h after extubation ( $n=1$ ) [3]. When compared to patients who succeeded weaning, patients who failed had greater tachycardia and exhibited a higher E wave maximal velocity (103 cm/s [84–140] vs. 81 cm/s [61–89]:  $p=0.002$ ), an increased E/A ratio (1.4 [0.9–2.3] vs. 0.9 [0.7–1.1]:  $p=0.002$ ), a shorter E wave deceleration time (110 ms [97–158] vs. 173 ms [130–212]:  $p=0.014$ ) and a higher tricuspid regurgitation peak velocity (3.37 m/s [2.70–3.87] vs. 2.83 m/s [2.57–3]:  $p=0.034$ ), while baseline left ventricular (LV) ejection fraction and LV outflow tract velocity–time integral were lower (29% [18–36] vs. 35% [26–40]:  $p=0.056$ ; and 14.5 [8.5–19.1] vs. 16.7 [13.5–21.1]:  $p=0.034$ , respectively). In contrast, no significant difference in the  $E'$  wave maximal velocity and  $E/E'$  ratio was noted (Table 1). During SBT, variations of Doppler

parameters were more marked in patients who failed than in those who succeeded weaning: higher increase of E wave maximal velocity (122 cm/s [92–160] vs. 93 cm/s [73–105]:  $p=0.002$ ) and of  $E/A$  ratio (1.7 [1–3.5] vs. 0.9 [0.7–1.3]:  $p=0.001$ ), and greater shortening of E wave deceleration time (88 ms [74–141] vs. 147 ms [105–174]:  $p=0.024$ ). Again, no significant difference was observed for the  $E'$  wave maximal velocity and  $E/E'$  ratio (Table 1). These data confirm those reported initially when dichotomizing patients according to passed or failed SBT [2].

Second, we investigated if the grade of LV diastolic dysfunction was associated with weaning failure [4]. Not surprisingly, the proportion of higher grades of LV diastolic dysfunction was significantly higher in patients who failed weaning, both at baseline and during SBT (Table 1). At baseline, grade 1 was more frequent in the “weaning success” group, whereas grades 2 and 3 were more prevalent in the “weaning failure” group (25/43 [58%] vs. 3/16 [19%] and 13/16 [81%] vs. 18/43 [42%], respectively:  $p=0.007$ ). This highlights the facilitating role of underlying diastolic dysfunction in precipitating LV overload at the origin of weaning-induced pulmonary edema [5].

Third, we performed a subgroup analysis in patients with chronic obstructive pulmonary disease ( $n=15$ ). In this subset of patients, those who failed weaning ( $n=4$ ) tended to have a higher E wave maximal velocity (119 cm/s [58–144] vs. 87 cm/s [61–96]:  $p=0.177$ ) and exhibited increased E/A ratio (1.2 [0.9–3.5] vs. 0.9 [0.7–1]:  $p=0.04$ ) at baseline.

Overall, these additional analyses confirm the leading role of LV overload in the weaning failure of patients at high risk of developing a weaning-induced pulmonary

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**Table 1 Hemodynamic parameters and echocardiographic findings obtained immediately before and during the first spontaneous breathing trial (SBT) according to weaning success or failure**

	Weaning success (n = 43)	Weaning failure (n = 16)	P value
<b>Before SBT</b>			
<b>Hemodynamic parameters</b>			
HR, bpm	90 (79–102)	114 (100–123)	0.001
sBP, mmHg	142 (130–151)	134 (130–151)	0.500
dBp, mmHg	78 (71–86)	81 (71–88)	0.511
mBP, mmHg	97 (87–107)	98 (85–109)	0.993
<b>Echocardiography findings</b>			
E, cm/s	81 (61–89)	103 (84–140)	0.002
A, cm/s	86 (70–106)	63 (44–125)	0.290
E/A	0.9 (0.7–1.1)	1.4 (0.9–2.3)	0.002
DTE, ms	173 (130–212)	110 (97–158)	0.014
E' lateral, cm/s	9.6 (7.4–12.2)	11.1 (8.2–15.4)	0.230
E/E'	7.9 (5.6–11)	9.2 (6.6–12.5)	0.170
MR/LA area	0.2 (0.17–0.25)	0.15 (0.13–0.2)	0.170
LVEF, %	35 (26–40)	29 (18–36)	0.056
LVOT VTI, cm	16.7 (13.5–21.1)	14.5 (8.5–19.1)	0.069
TR peak velocity, m/s	2.83 (2.57–3)	3.37 (2.7–3.87)	0.034
<b>Left ventricular diastolic dysfunction*</b>			
Grade 1	25 (58%)	3 (19%)	0.008
Grade 2	16 (37%)	9 (56%)	
Grade 3	2 (5%)	4 (25%)	
<b>During SBT</b>			
<b>Hemodynamic parameters</b>			
HR, bpm	96 (84–110)	121 (109–132)	0.002
sBP, mmHg	147 (126–156)	143 (120–166)	0.946
dBp, mmHg	78 (70–92)	89 (70–98)	0.314
mBP, mmHg	103 (90–110)	112 (89–116)	0.177
<b>Echocardiography findings</b>			
E, cm/s	93 (73–105)	122 (92–160)	0.002
A, cm/s	86 (75–112)	64 (33–117)	0.127
E/A	0.9 (0.7–1.3)	1.7 (1–3.5)	0.001
DTE, ms	147 (105–174)	88 (74–141)	0.024
E' lateral, cm/s	9.9 (8–11.3)	12.5 (8–16.1)	0.079
E/E'	9.5 (7.2–12.7)	9.6 (7.8–13.5)	0.500
MR/LA area	0.21 (0.16–0.23)	0.26 (0.14–0.39)	0.330
LVEF, %	33 (25–43)	27 (15–37)	0.087
LVOT VTI, cm	17.8 (14.4–20.8)	12.9 (8.2–18.9)	0.012
TR peak velocity, m/s	3 (2.75–3.3)	3.44 (3.1–4.16)	0.047
<b>Left ventricular diastolic dysfunction*</b>			
Grade 1	19 (44%)	3 (19%)	0.007
Grade 2	22 (51%)	6 (38%)	
Grade 3	2 (5%)	7 (43%)	

HR heart rate, sBP systolic blood pressure, dBp diastolic blood pressure, mBP mean blood pressure, DTE deceleration time of mitral E wave, MR mitral regurgitation, LA left atrium, LVEF left ventricular ejection fraction, LVOT left ventricular outflow tract, VTI velocity–time integral, TR tricuspid regurgitation

\* According to [4]

edema. Whether a therapeutic strategy based on such hemodynamic assessment could facilitate weaning in this targeted population remains to be determined.

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**Compliance with ethical standards****Conflicts of interest**

Authors have no conflicts of interest to declare.

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Accepted: 24 July 2020

Published online: 6 August 2020

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