

Supplemental Digital Content 2: Univariate/Bivariate Analyses of Variables Associated with Bundled Lung Protective Ventilation Strategy

Characteristic	Bundled LPV Strategy †		
	No N= 2781 (59.3%) n (%) or mean(SD)/ median [interquartile range]	Yes N = 1913 (40.8%) n (%) or mean(SD)/ median [interquartile range]	p-value
Preoperative Characteristics			
Age	62 (14)	62 (14)	0.8255
Sex, male	1514 (54.4)	1510 (78.9)	<.0001
Race, non-white	327 (11.8)	188 (9.9)	0.0366
Height, cm	169 (11)	175 (9)	<.0001
Actual Body Weight, kg	86.7 (22.2)	87.2 (19.2)	0.3640
Predicted Body Weight, kg	63.2 (11.6)	69.7 (9.2)	<.0001
Body mass index, kg/m ²			<.0001
Underweight (<18.5)	29 (1.0)	23 (1.2)	
Normal weight (18.5-24.9)	607 (21.8)	483 (25.3)	
Overweight (25-29.9)	939 (33.8)	785 (41.0)	
Class I Obesity (30-34.9)	623 (22.4)	442 (23.1)	
Class II Obesity (35-39.9)	316 (11.4)	132 (6.9)	
Class III Obesity (≥40)	267 (9.6)	48 (2.5)	
Current Smoker	459 (16.5)	171(8.9)	<.0001
Chronic Lung Disease *	312 (11.2)	231 (12.1)	0.3649
Recent Pneumonia within one month	25 (0.9)	30 (1.6)	0.0387
Sleep Apnea	204 (7.3)	286 (15.0)	<.0001
Pulmonary Hypertension	594 (21.4)	853 (44.6)	<.0001
Moderate (PA systolic pressure 31-55 mmHg)	459 (16.6)	726 (38.0)	
Severe (PA systolic pressure >55 mmHg)	135 (4.9)	127 (6.7)	
New York Heart Association Class			<.0001
I	2116 (77.4)	1691 (88.4)	
II	231 (8.5)	74 (3.9)	
III	310 (11.3)	99 (5.2)	
IV	76 (2.8)	49 (2.6)	
Recent Myocardial Infarction within 21 days	183 (6.6)	146 (7.6)	0.1659
Preoperative Left Ventricular Ejection Fraction, %	60 [55, 65]	60 [55, 65]	0.0062
Poor Mobility **	1491 (53.6)	862 (45.1)	<.0001
Extracardiac Arteriopathy	479 (17.2)	452 (23.6)	<.0001
Peripheral Arterial Disease	160 (5.8)	173 (9.0)	
Carotid Disease	289(10.4)	313 (16.4)	
Amputation for Arterial Disease	35 (1.3)	34 (1.8)	
Previous Major Vascular Surgical Intervention	126 (4.5)	98 (5.1)	
Dyslipidemia	1371 (49.3)	1332 (69.6)	<.0001
Arrhythmia ***	425 (15.3)	310 (16.2)	0.3908
Renal Impairment			
Creatinine Clearance, mL/min/1.73 m ² ****	75.0 (25.5)	78.8 (22.9)	<.0001
Dialysis Requirement	68 (2.5)	36 (1.9)	0.1989
Diabetes treated with Insulin	237 (8.5)	137 (7.2)	0.0911
Liver Disease	29 (1.0)	48 (2.5)	0.0002
Cancer	81 (2.9)	144 (7.5)	<.0001
Active Endocarditis	150 (5.4)	88 (4.6)	0.2238
Critical Preoperative State	193 (6.9)	217 (11.3)	<.0001
Preoperative Ventilation (exclusion)	(exclusion)	(exclusion)	
Preoperative Inotropic Support	168 (6.0)	198 (10.4)	
Cardiogenic Shock	13 (0.5)	11 (0.6)	
Intra-aortic balloon pump	32 (1.2)	26 (1.4)	
Hemoglobin, g/dL	13.2 (1.9)	13.8 (1.9)	<.0001
Platelet Count, K/uL	231 (73)	215 (63)	<.0001
White Blood Cell Count, K/uL	6.9 [5.8, 8.4]	6.7 [5.6, 8.1]	0.0001
International Normalized Ratio	1.0 [0.9, 1.1]	1.0 [1.0, 1.1]	0.0035
Preoperative SpO ₂ , %	97 [96, 98]	97 [96, 98]	0.0020
Preoperative Respiratory Rate	16 [16, 18]	16 [16, 16]	<.0001
Acuity			0.0007
Elective	2170 (78.0)	1570 (82.1)	
Urgent	611 (22.0)	343 (17.9)	

Surgical Procedure Type				0.0977
	Aortic Valve + Aortic	56 (2.0)	44 (2.3)	
	Valve + Aortic + CABG	535 (19.2)	392 (20.5)	
	Isolated CABG	51 (1.8)	33 (1.7)	
	Isolated Valve	543 (19.5)	426 (22.3)	
	Valve + CABG	1264 (45.5)	814 (42.6)	
		332 (11.9)	204 (10.7)	
Admission Type				<.0001
	Admit	2002 (72.0)	1486 (77.7)	
	Inpatient	779 (28.0)	427 (22.3)	
Date of surgery by STS Version				<.0001
	2.52 (Jan 2006-Dec 2007)	324 (11.7)	25 (1.3)	
	2.61 (Jan 2008-June 2011)	1031 (37.1)	255 (13.3)	
	2.73 (July 2011-June 2014)	1136 (40.9)	543 (28.4)	
	2.81 (July 2014-May 2017)	290 (40.4)	1090 (57.0)	
ASA Physical Status				0.0065
	3	917 (33.0)	559 (29.2)	
	4	1864 (67.0)	1354 (70.8)	
Intraoperative Characteristics				
Perfusion Time, hours		2.2 (1.0)	2.2 (1.1)	0.1006
Aortic Crossclamp Time, hours		1.7 (0.8)	1.7 (0.9)	0.5292
Anesthesia Duration, hours		6.5 [5.4, 7.7]	6.6 [5.4, 8.1]	0.0009
Anesthesia Provider*****				<.0001
	Low LPV User	1698 (61.1)	791 (41.4)	
	Medium LPV User	959 (34.5)	885 (46.3)	
	High LPV User	124 (4.5)	237 (12.4)	
Intraoperative Albuterol		42 (1.5)	15 (0.8)	0.0285
Intraoperative Diuretic *****		1313 (47.2)	1585 (82.9)	<.0001
Intraoperative Vasopressor infusion (phenylephrine, norepinephrine, vasopressin)		2432 (87.5)	1862 (97.3)	<.0001
Intraoperative Inotrope infusion (epinephrine, dobutamine, milrinone, isoproterenol, dopamine)		1152 (41.4)	571 (29.9)	<.0001
Total intraoperative opioid, oral morphine equivalents		300 [255, 375]	300 [276, 330]	0.8234
Total intraoperative crystalloid, L		3.0 [2.0, 4.3]	3.0 [2.2, 4.2]	0.2809
Total intraoperative colloid, L		0 [0, 0.5]	0 [0, 0.5]	0.4325
Intraoperative packed red blood cells, units		1 [0, 2]	0 [0, 0]	<.0001
Intraoperative red blood cell salvage, L		0 [0, 0]	0 [0, 0]	0.0009
Fresh frozen plasma, units		0 [0, 0]	0 [0, 0]	<.0001
Platelets, units		0 [0, 1]	0 [0, 0]	<.0001
Cryoprecipitate, units		0 [0, 0]	0 [0, 0]	<.0001
Total urine output, L		1.9 (1.2)	1.9 (1.1)	0.7098
Pre-CPB Ventilator / Respiratory Parameters				
Tidal volume, mL/kg predicted body weight		8.5 (1.5)	6.9 (0.8)	<.0001
Peak Inspiratory Pressure, cm H ₂ O		18 [16, 22]	16 [14, 18]	<.0001
Positive End-Expiratory Pressure, cm H ₂ O		4 [0, 5]	5 [5, 5]	<.0001
Driving Pressure, cm H ₂ O		15 [13, 19]	11 [10, 13]	<.0001
SpO ₂ , %		99 [99, 100]	99 [98, 100]	<.0001
Inspired FIO ₂ , %		97 [96, 98]	97 [92, 98]	<.0001
Post-CPB Ventilator / Respiratory Parameters				
Tidal volume, mL/kg predicted body weight		8.4 (1.5)	6.8 (0.7)	<.0001
Peak Inspiratory Pressure, cm H ₂ O		19 [16, 22]	17 [15, 18]	<.0001
Positive End-Expiratory Pressure, cm H ₂ O		4 [2, 5]	5 [5, 5]	<.0001
Driving Pressure, cm H ₂ O		15 [12, 18]	11 [10, 13]	<.0001
SpO ₂ , %		100 [99, 100]	99 [99, 100]	0.1634
Inspired FIO ₂ , %		97 [96, 98]	97 [96, 98]	<.0001

ASA = American Society of Anesthesiologists; CABG = coronary artery bypass graft; CPB= cardiopulmonary bypass; FIO₂ = fraction of inspired oxygen; LPV = lung-protective ventilation; PA = pulmonary artery; STS = Society of Thoracic Surgeons

Study exposure variable presented in **bold/italic**.

† Defined as intraoperative median values of: tidal volume <8 mL/kg predicted body weight, positive end-expiratory pressure ≥5 cm H₂O, and driving pressure <16 cm H₂O

* Defined by chronic lung disease ≥ moderate or bronchodilator therapy within STS; or chronic obstructive pulmonary disease ≥ moderate on preoperative anesthesia history & physical

** Defined by functional capacity – Low (≤4 metabolic equivalents of task) on preoperative anesthesia history & physical

*** Defined via STS as a history of any of the following: atrial fibrillation, atrial flutter, 3rd degree heart block, ventricular fibrillation, ventricular tachycardia

**** Calculated using the Chronic Kidney Disease – Epidemiology Collaboration equation

***** Defined as the frequency of primary anesthesiology attending using a bundled LPV strategy, as a proportion of all cardiac cases performed by the anesthesiology attending among the study population, transformed into tertiles.

***** Defined as intraoperative administration of furosemide, bumetanide, or mannitol

P-value from independent t-Test, Mann-Whitney U Test, or Chi-Square Test, as appropriate.