

Supplementary Table 1: Cardiopulmonary Outcomes Following Pectus Repair

Year	Study	Design	Patient Demographics	Mean Haller Index	Follow up post-surgery (months)	Bar/No bar	Cardiopulmonary outcomes	Results
2022	Jaroszewski	Retrospective cohort study Uncontrolled Single centre	n = 130 Age 32.4 ±10 Nuss	4.6 ±2.2	36	Bar	CPET TOE (n =36)	Significant increase in VO_{2max} , 26.1±6.8 to 29.1±8.5 ml/kg/min (70.8±17.0 to 82.5±22.0 % predicted) and significant increase in O_2 pulse 11.8±3.4 to 13.1±3.8 ml/beat (83.0±17.4 to 92.2±24.2 % predicted). Significant increase in RV function: RVOT 14.2±3.3cm to 16.3±3.4cm (p< 0.005) and RV SV 41.1±13.2ml to 54.6±15.6 (p < 0.001).
2021	Lain	Prospective cohort study Uncontrolled Single centre	n = 20 Age 13.5± 2.9 Nuss	6.3 ±2.63	Intraoperative	Bar	TOE	Significantly increase in diameter of right ventricle was 5.78 +/- 3.5mm (p < 0.05), right atrium 6.64 +/- 5mm (p < 0.05) and tricuspid annulus 6.02+/- 3.29mm (p < 0.05).
2021	Del Frari	Prospective cohort study Uncontrolled Single centre	n = 19 Age 13.9-19.6 Nuss	4.2 ± 1.0	9	Bar	PFT TTE CPET	No significant change in variables. No significant change in variables: RVEDV 32.0 ± 2.57mm and LVEDV 45.0 ± 4.67mm baseline w/ no change post-op. No significant change in variables: VO_{2max} 41.0 ± 6.2 to 40.4 ± 4.0 ml/kg/min.
2019	Das	Retrospective cohort study Uncontrolled Single centre	n = 24 Age 12.9±3.6 Nuss	4.3±0.9	24	Bar	CPET	Significant improvement in VO_{2max} by 40.6%: 32 ± 13 to 45 ± 10 ml/kg/min (p = 0.0001) Significant improvement in oxygen pulse by 44.4%: 9 ± 4–13 ± 5 ml/beat (p = 0.03).
2018	Kuyama	Retrospective cohort study Uncontrolled Single centre	n = 43 Paediatric Nuss	4.3 ± 1.3	48	No bar	PFT	FVC fell post bar insertion but significantly increased 1 year post bar removal.

										CPET	No significant change in variables: VO_{2max} 30.4 ± 1.9 to 33.3 ± 1.6 ml/kg/min ($p = 0.0940$).
2016	Udholm	Prospective cohort study Uncontrolled Single centre	n = 15 Age 32 Nuss	NR		12	Bar			PFT	No significant change in variables: FVC 90 ± 9 to $88 \pm 7\%$ ($p = 0.2731$), FEV1 89 ± 10 to $90 \pm 9\%$ /predicted ($p = 0.7896$).
2015	Kuru	Prospective cohort study Uncontrolled Single centre	n = 80 Age 16.91 ± 4.37 Nuss	4.07 ± 1.4		6	Bar			PFT	No significant change in FEV1. Significant decrease in FVC decreased from $83.21\% \pm 16.97\%$ to $76.52\% \pm 20.98\%$ ($p = 0.01$).
2016	Toepper	Prospective cohort study Uncontrolled Single centre	n = 38 Age 21 ± 8.3 Nuss	9.64 ± 22		12	Bar			cMRI	Significant decrease in heart rate ($p < 0.0001$) Significant increase in RVEF ($p = 0.0004$), RVSV ($P = 0.0167$), LVEF ($p = 0.0165$), and LVSV ($p = 0.0036$). No significant change in RVEDV ($p = 0.7590$), RVESV ($p = 0.0718$), LVEDV ($p = 0.0648$), and in LVESV ($p = 0.8135$).
2015	Chao et	Retrospective cohort study Uncontrolled Single centre	n = 168 Age 33 (18-71) Nuss	5.7 ± 3.1	Intraoperative		Bar			TOE	Significant improvement in RA (15.1%), tricuspid annulus end systolic (10.9%), right ventricular outflow tract end diastolic (6.1%) and end systolic dimension (6.1%) size after surgery (all $P < 0.0001$). Significant improvement in right ventricular cardiac output by 38% ($P < 0.0001$).
2014	Gurkan	Retrospective cohort study Uncontrolled Single centre	n = 16 Age 20.5 ± 5.6 Nuss	NR			1	Bar		TTE	Significant increase in RV end-diastolic diameter, tricuspid annular plane systolic excursion (TAPSE), pulsed tissue Doppler systolic velocity (S'). Significant improvement in myocardial performance indexes of both the right and the left ventricles.
2013	Szydluk	Retrospective cohort study Uncontrolled Single centre	n = 44 Age 16 (10-32) Nuss	NR			40	No Bar		PFT	Significant improvement in FVC, 75 to 89% ($P = 0.00016$) and FEV1, 85% to 95% ($p = 0.0125$).

2013	O'Keefe	Prospective cohort study Uncontrolled Single centre	n = 67 Age 13.9 ± 2.3 Nuss	4.4 ± 1.3	42	No bar	PFTs CPET TTE Subjective exercise tolerance	Significant improvements in FEV1, 81±17 to 89. ±20.5 % predicted (p < 0.001) and FVC, 91.2±18.6 to 98.9 ± 22 % predicted (p < 0.01). Significant improvements in O ₂ pulse 75.8 ± 14.4 vs 80.5 ± 18.3* % predicted (P < 0.01) but no significant change in VO _{2Max} , 33.2±7.5 to 34.2±7.5ml/kg/min (p = 0.09). No significant change in variables. Subjective ability to exercise (3.3± 0.7 vs 4.3 ± 0.6, scale 1–5) increased significantly.
2013	Maagard	Prospective cohort study Controlled (age matched healthy controls) Single centre	n = 68 (42patients, 24 controls) Age 15.5 ± 1.7 Nuss	4.9 ± 1.4	36	No bar	PFT TTE CPET	Low normal function in patients pre-operatively w/ significant improvement in FEV1 1-year (p = 0.001) and 3-year follow-ups (p = 0.0001), patients improved FEV1 compared with baseline and were no longer different from controls. No significant difference between patients and controls or pre and post-surgery. Before correction, C _{lmax} was lower in patients compared with controls during exercise, 6.6±1.2 vs 8.0±1.7 mL/min/m ² . Increased both from 1-year to 3-year follow-up (p = 0.001) and from baseline to 3-year follow-up (p = 0.0001). After bar removal at the 3-year follow-up, C _{lmax} had normalized and no significant difference was seen between patients and controls, 8.1±1.2 and 8.3±1.6 (p = 0.572).
2013	Kelly	Prospective cohort study Controlled (age matched healthy controls) Multicentre	n = 182 / n = 20 13.56 ± 3 Nuss/Ravitch	4.4	12	Bar	PFT CPET	Significant increase in FVC from 88% to 93%, FEV1 from 87% to 90%, and TLC from 94% to 100% of predicted (p < 0.001 for each). VO _{2max} increased by 10.1%, 3.18±0.3 to 3.50±0.3 L/min (p = 0.015) and O ₂ pulse by 19%, 13.58±3 to 16.16±4.9 (p = 0.007).

		Prospective cohort study Controlled (age matched healthy controls)	n = 75 (49 patients, 26 controls) Age 15.5 ± 1.7					PFT TTE	FEV1 was low normal (87%) w/ significant difference between patients and controls (94%) which increased significantly to 91% 1 year post op (P < 0.01) however still remained lower than controls. No significant change in variables.
2012	Tang	Single centre	Nuss	5.3 ± 2.3	12	Bar	CPET		No significant change in VO _{2max} , 26±6 to 28±6 ml/kg/min, Maximum cardiac index was significantly improved at 1 year postoperatively, 6.6± 1.1 to 7.2± 1 L/min/m ² (P = 0.0054) but was still significantly lower than the control group (P = 0.0008).
2012	Schaarschmidt	Prospective cohort study Uncontrolled Single centre	n = 51 Age 21.1±8.6 Nuss	8.3±3.6	12	Bar	CMR		Right and left ventricular ejection fraction and right ventricular stroke volume (SV) are significantly increased 2 weeks (p < 0.001) and 3 month (p < 0.001) after Nuss (similar trend in the few patients 1 year post).
								PFT TTE	No significant change in variables. No significant change in variables.
2011	Neviere	Prospective cohort study Uncontrolled Single centre	n = 70 Age 27 ± 11 Ravitch	4.7 ± 1.4	12	Ravitch	CPET		Significant increase in VO _{2max} 34.9±7 to 37.6±7 (77 ±2% to 87±2 % predicted) (P < 0.0005) and O ₂ pulse 13.2±3 to 14.8± 3 (P<0.003).
2010	Krueger	Prospective cohort study Uncontrolled Single centre	n = 17 Age 28 (17–54) Ravitch	NR	Intraoperative	Ravitch	TOE		Significant increase in RVED diameter, area, volume; 2.4 ± 0.8 cm versus 3.0 ± 0.9 cm, (p < 0.001); 12.5 ± 5.2 cm ² versus 18.4 ± 7.5 cm ² , (p < 0.001); and 21.7 ± 11.7 mL versus 40.8 ± 23 mL, (p < 0.001) and LV function 58.4% ± 15% versus 66.2% ± 6%, (p < 0.001).
2010	Sigalet	Prospective cohort study Uncontrolled Single centre	n = 26 Age 13.2 ± 2.1 Nuss	4.5 ± 1.3	40	No bar	CPET	PFT	Significant improvement in FEV1 78 ± 16 to 84 ± 18 % predicted (p < 0.05) and TLC 95 ± 16 to 99 ± 14 % predicted (p < 0.05), no significant change in FVC 89.5 ± 18 to 92.4 ± 20 % predicted. Significant improvement in VO _{2max} 71 ± 11 to 77 ± 11 % predicted, (p < 0.05) and O ₂ Pulse 77.1 ± 9.5 to 82.5 ± 9.2 % predicted (p < 0.05).

2010	Cooper	Prospective cohort study Uncontrolled Single centre	n = 28 Age 24 ± 14 Nuss	8.89±5	9	Bar	PFT cMRI CPET	No significant change in TLC. RVSV increased by 11 ml (p = 0.005). VO _{2max} 2.37 to 2.6 L/min (p = 0.002).
2010	Castellani	Prospective cohort study Uncontrolled Single centre	n = 59 Age 15.7 ± 4.5 Nuss	Different index	3.5	No bar	PFT CPET	Transient FVC decreased from 91% of normal value to 79%, but again increased to 88% after implant removal (no significant difference long term.) No significant change in VO _{2max} 42.6±6 to 42.2±7.2 ml/kg/min.
2007	Kubiak	Retrospective cohort study Uncontrolled Single centre	n = 15 Age 15.9 Nuss	6 ± 2.1	40	No bar	PFT	Significant improvement in FVC 63.7 to 81.3 % predicted (p = 0.03), FEV1 62.9 to 84.7% %predicted (p = 0.03) and the RV/TLC ratio, 173.7 to 118.9 (p < 0.001).
2007	Aronson	Prospective cohort study Uncontrolled Multicentre	n = 145 Age 14.9 ± 6 Nuss	NR	36	No bar	PFT	No significant change in PFTs from pre-op values after bar removal. PFTs were normal pre-op and majority of patients were operated on for cosmetic reasons.
2006	Coln	Retrospective cohort study Uncontrolled Single centre	n = 123 Age 13 (5-18) Nuss	4.3±1.6	24	Bar	TTE (during exercise)	Cardiac compression in 117 (95%) and mitral valve abnormality was present in 54 (44%) on TTE during exercise Significant reduction in cardiac compression, normal post-op echo in 100 patients (93%).
2005	Lawson	Retrospective cohort study Uncontrolled Single centre	n = 45 Age 11.4 Nuss	4.6 ± 2	48	No Bar	PFT	Preoperatively, FVC and FEV1 medians were lower than the normal by 13%, whereas the FEF25-75 median was lower than normal by 20% (all P < 0.01). Small but significant improvement: 6% improvement in FVC, 9% improvement in FEV1, and a 15% improvement in FEF25-75.
2000	Jiang	Prospective cohort study Uncontrolled Single centre	n = 27 Age: 8.6 (3-16) Ravitch	NR	24	Ravitch	PFT	No significant change in variables.
2000	Haller	Prospective cohort study		NR	6	Ravitch	PFT	Lower FVC in patients versus controls but no significant change post repair.

		Controlled (age matched healthy controls)	46 (36 patients and 10 controls)								
			Age 16 ± 3								
		Single centre	Ravitch								Exercise testing
											Significant increases in duration (P < 0.02), speed (P < 0.02), and grade of exercise (P < 0.05) and in O ₂ pulse (P < 0.005).
1998	Kowaleski	Retrospective cohort study	34 (22 moderate, 12 severe)	Different index							PFT
		Uncontrolled	Age 13 (4-35)								
		Single centre	Ravitch	used		5	Ravitch		TTE		Significant improvement in FEV1 only in those w/ severe ventilatory impairment pre-operatively.
											No improvement in LV function but significant improvement RV diastolic volume and SV index following surgery.
1994	Morshuis	Prospective cohort study	n = 35								PFT
		Uncontrolled	Age 17.9 ± 5.6								
		Single centre	Ravitch	NR		12	Ravitch				Exercise testing
											TLC 86.0% +/- 14.4%; (p = 0.0001) and FVC 79.7% +/- 16.2; (p = 0.0001) were significantly smaller than predicted and further decreased after operation -9.2% +/- 9.2%; (p = 0.0001) and -6.6% +/- 10.7% (p = 0.0012). Significant increase in VO _{2max} (p = 0.0002) and O ₂ pulse (p = 0.0333).
1992	Kaguraoka	Retrospective cohort study	n = 138	Different index							PFT
		Uncontrolled	Age 19.6 ± 7.6			42	Ravitch				
		Single centre	Ravitch								
		Prospective cohort study									
		Controlled (PEX not undergoing surgery)	12 (8 patients, 4 PEX controls)	Different index							
1990	Wynn	Single centre	Age 13.6			12	Ravitch				Exercise testing
			Ravitch								No significant changes pre or post operation: VO _{2max} 36.1 ± 4.4 to 38.1 ± 8.1 ml/kg/min in study group and 41.2 ± 7.3 to 43.0 ± 6.9ml/kg/min in control group.
1985	Peterson	Prospective cohort study	n = 13	Different index							First pass radionuclide cardiography
		Uncontrolled	Age 13 ± 4			6	Ravitch				
		Single centre	Ravitch								
											No changes in LVEF or cardiac index at rest or exercise, significant increase in RV end diastolic volume.

1985	Blickman	Prospective cohort study Uncontrolled Single centre	n = 17 Age 12.3 (4-21) Ravitch	NR	6	Ravitch	Perfusion and ventilation scintigraphy	Ventilation-perfusion ratios were abnormal in 10 of 17 patients, normalizing postoperatively in 60%.
1984	Cahill	Prospective cohort study Uncontrolled Single centre	n = 14 Age 11 ± 3 Ravitch	NR	6	Ravitch	Exercise testing	Significant improvement in maximal voluntary ventilation (p < 0.001), improvement in exercise performance quantified by the total exercise time and the maximal oxygen consumption (p < 0.01).

NR indicates not recorded; CPET, Cardiopulmonary exercise testing; PFT, Pulmonary function testing; TTE, Transthoracic echocardiography; TOE, Transoesophageal echocardiography, VO_{2max}; Maximum oxygen consumption; FVC; Forced vital capacity, FEV1; Forced expiratory volume in one second RV; Right ventricle; LV; Left ventricle