Abstract: P289

Diaphragm dysfunction following cardiac surgery: role of ultrasound imaging for initial and follow-up assessment during cardiac rehabilitation

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Background Diaphragm dysfunction is a common, but underdiagnosed complication of cardiac surgery. Ultrasonography (US) is an emerging technique for the assessment of diaphragm function. In cardiac surgery, few trials have been conducted using US and no clear data exist on the recovery of diaphragm function after surgery.

Purpose The aim of this study is to evaluate post-cardiac surgery diaphragm dysfunction using US and to assess the impact of an inpatient cardiovascular rehabilitation (CR) programme on its functional recovery.

Methods We performed a single-centre prospective cohort study, enrolling 97 consecutive patients hospitalised in our CR Unit. 38 patients underwent mitral valve repair or replacement, 14 aortic valve replacement, 14 coronary artery bypass grafting (CABG), 22 combined surgery, and 9 other surgical interventions. Diaphragm US was performed at admission and after 10 rehabilitative sessions. We assessed the following parameters: thickening fraction (TF) in B-mode on the right intercostal projections, and excursion, time of inspiration, time of a respiratory cycle and contraction velocity in M-mode on right anterior subcostal projections.

Results Following cardiac surgery, the incidence of diaphragm dysfunction and paralysis were 60% and 1%, respectively. Patients with TF <20% at admission gained an important benefit from rehabilitation, with significant improvement in TF (13.30%, IQR 8.69 – 17.39 vs 27.27%, IQR 21.05 – 31.58; p<0.001), excursion (1.67cm, IQR 1.3 – 2.1 vs 2.23cm, IQR 1.9 – 2.7; p<0.001), time of inspiration (0.9s, IQR 0.9 – 1.07 vs 1.01s, IQR 0.87 – 1.13; p=0.005), time of a respiratory cycle (2.67s, IQR 2.38 – 3.05 vs 3.07s, IQR 2.68 – 3.35; p<0.001) and velocity (1.81cm/s, IQR 1.14 – 2.33 vs 2.24cm/s, IQR 1.92 – 2.76; p<0.001). Conversely, in patients with a TF>20%, no additional improvement was observed. In both groups, there was a significant improvement in the parameters of physical performance. Patients with TF<20% showed an increase of the 6-minute-walking-distance (300m, IQR 205 – 370 vs 555m, IQR 450 - 612; p<0.001) and the corresponding METS (2.60, IQR 2.13 – 2.92 vs 4.09, IQR 3.44 – 4.50; p=0.001) and a reduction of the perception of exertion (Borg Scale 11, IQR 11 – 13 vs 13, IQR 12 - 13; p=0.011). At the final assessment, in 51.5% of the total population diaphragm function recovered, whilst 48.5% had a failure of recovery (TF relative change between admission and discharge < 60%). The multivariate analysis identified CABG as an independent predictor of failure of diaphragm recovery (OR 5.44; CI 1.10 - 26.84, p=0.037).

Conclusion US might be a valuable part of routine clinical practice for initial and follow-up assessment of patients after cardiac surgery. Rehabilitation showed to be an effective strategy to improve diaphragm parameters in patients with post-surgical dysfunction. Progressive evaluation of diaphragm function may drive personalised rehabilitation programmes.