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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 complication of cardiac surgery, often underdiagnosed. Ultrasonography (US) is a promising technique for diaphragmatic assessment. Few trials have been conducted using US after heart surgery and no clear data exist on the recovery of diaphragm function after cardiovascular rehabilitation (CR).

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

Methods: In a single-centre prospective cohort study 97 consecutive patients hospitalised in our CR Unit were enrolled. 14 patients underwent aortic valve replacement, 38 mitral valve repair or replacement, 14 coronary artery bypass grafting (CABG), 22 combined surgery, and 9 other surgical interventions. We performed diaphragm US at admission and after 10 rehabilitative sessions. The following parameters were assessed: 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: After cardiac surgery, the incidence of diaphragm dysfunction and paralysis were 60% and 1%, respectively. Patients with TF <20% at admission showed a 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). On the contrary, 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. In particular, in the group with a TF<20%, the distance covered during the 6MWT (300m, IQR 205–370 vs 555m, IQR 450–612; p<0.001) and the energy cost of physical activity (2.60, IQR 2.13–2.92 vs 4.09, IQR 3.44–4.50; p<0.001) increased while the perception of exertion (Borg Scale 11, IQR 11–13 vs 13, IQR 12–13; p=0.011) was reduced. At the 10th day assessment, 51.5% of the total population had a recovery of diaphragm function, 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 open-heart surgery. CR 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.