The endothelial glycocalix changes are associated with haemodynamic and metabolic responses in on-pump valve repair surgery

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Background & Goal

The endothelial glycocalix system is an important protective regulator of vascular integrity, permeability, cell interactions, and endothelial activation. The perioperative endothelial glycocalix shedding can be associated with capillary leak, haemodynamic and metabolic disturbances, as well as increased postoperative morbidity.

The goal of this pilot study was to assess the endothelial glycocalix response in the delayed period after elective uncomplicated on-pump valve repair surgery.

Methods

Twenty-six adult patients scheduled for elective valvular interventions on cardiopulmonary bypass were enrolled into a single-centre prospective observational study.

The components of endothelial glycocalix including **Heparan Sulfate Proteoglycan** (HSPG) and **Syndecan-1** (SYN1) were measured after the induction of anaesthesia, and at 6, and 24 hrs postoperatively (ELISA Kits for HSPG, SDC1, USA).

The haemodynamic variables, including cardiac index (CI), systemic vascular resistance index (SVRI), pulse pressure variations (PPV), arterial and venous blood gases, N-terminal pro brain natriuretic peptide (NT-proBNP), lactate, and venous glucose concentrations were measured perioperatively.

The statistical analysis was performed using Mann–Whitney *U*-test, ANOVA, Spearman’s *rho*, and ROC-analysis. Data are presented as median (25th–75th percentiles). *p* values < 0.05 were regarded as statistically significant.

Results & Discussion

The key haemodynamic and metabolic variables involved in the associations with endothelial glycocalix components are presented in Table 1. At 6 hrs postoperatively, cardiac index increased significantly compared with the induction of anaesthesia.

At 6 hrs after surgery, we observed a 16% decrease in HSPG concentration from 6.13

Table 1. The changes of key study parameters.

Parameter	Stage		
	Baseline	6 hrs	24 hrs
SVRI, dyn×sec×cm ⁵ /m ²	2807 (1771–3843)	2098* (1356–2840)	2291* (1539–3043)
CI, L/min/m ²	1.97 (1.43–2.51)	2.64* (1.75–3.53)	2.41* (1.84–2.98)
PPV, %	n/a	6 (1–11)	8 (0–16)
Glucose, mmol/L	5.9 (5.1–6.7)	11.3* (8.9–13.9)	9.2* (7.1–11.2)
Lactate, mmol/L	0.7 (0.5–1.0)	2.1* (1.5–2.7)	2.0* (1.3–2.6)

* — *p* < 0.05 using ANOVA compared with Baseline (after induction of anaesthesia).
SVRI — Systemic Vascular Resistance Index; CI — Cardiac Index; PPV — Pulse Pressure Variations.

Figure 1. The changes of heparan sulfate proteoglycan and Syndecan-1 throughout the study period.

* — *p* < 0.05 using ANOVA compared with the values on Baseline.

Figure 2. The correlation between baseline values of NT-proBNP and heparan sulfate proteoglycan at 6 hrs postoperatively.

NT-proBNP — N-terminal pro Brain Natriuretic Peptide.

Figure 3. ROC-curve for the value of Heparan Sulfate Proteoglycan, measured at baseline to predict postoperative hyperlactataemia (above 2 mmol/L).

Cut-off point of heparan sulfate proteoglycan ≤ 7.72 ng/mL (sensitivity 100 % and specificity 58.3 %).

(4.20–9.04) ng/mL to 5.08 (4.18–7.21) ng/mL (*p* < 0.01), while SYN1 significantly increased by 47% from 0.80 (0.56–1.13) ng/mL to 1.25 (1.04–1.41) ng/mL (*p* < 0.001). At 24 hrs, HSPG and SYN1 returned to values close to baseline (Figure 1).

The baseline HSPG correlated with systemic vascular resistance index (*rho* = –0.55 *p* = 0.004), postoperative cardiac index (*rho* = 0.43–0.46, *p* = 0.03), pulse pressure variations (*rho* = –0.76, *p* = 0.003), and glucose concentration (*rho* = –0.50, *p* = 0.02).

The baseline NT-proBNP demonstrated weak correlation with HSPG concentration at 6 hrs after surgery (*rho* = 0.42, *p* = 0.04) (Figure 2).

In addition, the baseline HSPG concentrations below 7.72 ng/mL predicted postoperative hyperlactataemia (≥ 2 mmol/L) with AUC 0.75, sensitivity 100% and specificity 58.3 % (*p* = 0.02) (Figure 3).

The values of HSPG at all stages and the baseline SYN1 concentration correlated with duration of mechanical ventilation (*rho* = 0.46–0.49, *p* < 0.02).

Conclusions

At the selected perioperative time-points, the endothelial glycocalix system demonstrated relatively minor shedding to the elective on-pump cardiosurgical interventions and moderate associations with haemodynamics, metabolic response, and the duration of respiratory support.

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