Novel non-invasive imaging method for baseline risk stratification in cardiac surgery patients

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DESCRIPTION

Postoperative mortality rates in cardiac surgery remain elevated when compared with other types of surgery.^{1,2} In particular, postoperative complications can involve several organs and may have a major impact on the length of hospital stay and quality of life following surgery.² Current clinical risk prediction models often contain a large number of variables, are time-consuming to calculate and do not perform well on individual bases.^{3,4} Herein, we present and discuss a novel non-invasive microcirculatory imaging method as a risk stratification tool for cardiac surgery patients.

A 71-year-old woman with a history of hypertension was admitted to our institute with suspected cardiac asthma, presenting as an non-ST-elevation myocardial infarction (NSTEMI) with mitral insufficiency grades 3–4. Following coronary angiogram examination, the patient was diagnosed with three-vessel disease and scheduled for coronary bypass surgery with mitral valve replacement. Preoperative blood analysis showed acceptable levels of serum creatinine 79 µmol/L, C reactive protein 12.8 mg/L and white cell count $8.7 \times 10^9/L$. Thereby clinicians deemed the patient suitable for surgery. Retrospective risk assessment of acute renal failure using the Thakar *et al* score⁵ predicted a 2.06% risk of requiring postoperative dialysis.

Non-invasive sublingual microcirculation assessment was performed using incident dark field imaging (IDFI) (Cytocam-IDFI, Braedius, Huizen, Amsterdam, The Netherlands),⁶ immediately following anaesthesia induction. The Cytocam emits green light at 348 nm wavelength which corresponds to the isosbestic absorption range of haemoglobin, thereby enabling real-time visualisation of red blood cell behaviour within the microvascular bed. The camera was placed into the sublingual cave immediately adjacent to the lingual frenulum, 1–2 cm from the base of the tongue. Image sequences consisting of 150 frames were captured, which revealed substantial microcirculatory leucocytosis with areas of heterogeneous microvascular perfusion (video 1). Leucocytes expressed as bright white globules could be seen sticking and rolling on the wall of the endothelium within the capillary to postcapillary venule unit (figure 1). The direct visualisation of leucocyte adhesion to the endothelial surface at the baseline incurs the presence of compromised endothelial barrier and endothelial hyperpermeability.⁷ The degradation of the glycocalyx must occur for the expression of adhesion molecules which are required for leucocyte-endothelial adhesion and subsequent diapedesis.⁷

During surgery, low dose norepinephrine was administered to maintain adequate blood pressure and heart rate. The patient required a total extracorporeal circulation time of 237 min. Overall, the surgery was uncomplicated. An attempt at microcirculatory monitoring was made at the end of surgery during skin closure. However, due to excessive bleeding within the oral cavity (from heparin administration), image sequences captured were not of sufficient quality for analysis.⁶ During cardiac surgery, blood present within the oral cavity alongside pressure artefacts induced within

Figure 1 (A) Screenshot of the Cytocam-incident dark field captured video clip of the sublingual microcirculation immediately following anaesthesia induction. The red outline indicates a capillary to postcapillary venule (C-PCV) unit. Observation of the C-PCV unit is important for studying leucocyte behaviour within the microcirculation, as leucocyte velocity will change progressing from the capillary into the PCV. Microcirculatory parameters were determined using Automated Vascular Analysis V. 3.2 (Microvision Medical, Amsterdam, The Netherlands), which revealed: total vessel density 26.25 mm/mm², functional capillary density 20.14 mm/mm², portion of perfused vessel 76.75% and mean flow index 1.75. (B) Blue arrows indicated leucocytes, expressed as bright white globules, adhered to the endothelial surface. This creates characteristic 'bite mark' appearances on the endothelial wall.

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Video 1 Image sequences captured using Cytocam-Incident Dark Field imaging of the sublingual microcirculation immediately following anaesthesia induction. Heterogeneous perfusion in the capillary networks can be observed. Leukocytes expressed as bright white globes can be clearly seen tethered to the endothelial wall of post capillary venule units and the larger vessels.

the sublingual view from the transthoracic echo and mechanical ventilation presents a major limitation of this technique.

Following Intensive Care Unit admission, the patient was diagnosed with acute kidney injury (AKI) based on a 55 $\mu\text{mol/L}$ increase in serum creatinine levels and low urine volume output. Within 48 hours after surgery, the patient developed anuria and was placed on dialysis. From which the patient did not recover and died in the ICU from multiple organ failure within 5 days of admission. Impairment of endothelial barrier detected at the baseline with further exposure to the non-physiological conditions of the cardiopulmonary bypass, fluid shift and inflammation may further contribute to endothelial damage.^{8 9}

Learning points

- Visualisation of microvascular leucocyte—endothelial adhesion incur the presence of compromised endothelial barrier.
- Microcirculation monitoring may be a non-invasive risk stratification tool in cardiac surgery patients.

This is the first report demonstrating the presence of endothelial barrier dysfunction preceding the development of serious postoperative complications following cardiac surgery in a non-invasive manner. Sublingual microcirculation monitoring as a risk stratification tool may be useful for predicting outcomes at the patient level. The device is portable, easy to set up and cost-effective to run. Thereby, routine bedside evaluations may provide clinicians with crucial information on the integrity of the microcirculation. These simple correctable dysfunctions may be acted on (ie, off-pump surgery) to reduce the risk of postoperative complications. Future investigations should examine the hypothesis between baseline microcirculation derangements and complications following cardiac surgery in a bigger cohort study.

Contributors LS was involved in the data collection of the microcirculatory images, the analysis of data using Automated Vascular Analysis and the design of the case report. JCdV was also involved in the collection of clinical data, analysis of data and gave critical feedback during the drafting of the manuscript. CI gave critical intellectual insight into the interpretation of the microcirculatory data. WJvB was involved in the data collection process, the design of the case report, and gave critical feedback on the interpretation of data. All authors were involved in the writing and approved the final manuscript.

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REFERENCES

- 1 Nashef SAM, Roques F, Sharples LD, *et al.* EuroSCORE II. *Eur J Cardiothorac Surg* 2012;41:734–45.
- 2 Ball L, Costantino F, Pelosi P. Postoperative complications of patients undergoing cardiac surgery. *Curr Opin Crit Care* 2016;22:386–92.
- 3 Vives M, Hernandez A, Parramon F, *et al.* Acute kidney injury after cardiac surgery: prevalence, impact and management challenges. *Int J Nephrol Renovasc Dis* 2019;12:153–66.
- 4 Shaw A, Raghunathan K. Fluid management in cardiac surgery. *Anesthesiol Clin* 2013;31:269–80.
- 5 Thakar CV, Arrigain S, Worley S, *et al.* A clinical score to predict acute renal failure after cardiac surgery. *J Am Soc Nephrol* 2005;16:162–8.
- 6 Ince C, Boerma EC, Cecconi M, *et al.* Second consensus on the assessment of sublingual microcirculation in critically ill patients: results from a task force of the European Society of intensive care medicine. *Intensive Care Med* 2018;44:281–99.
- 7 Constantinescu AA, Vink H, Spaan JAE. Endothelial cell glycocalyx modulates immobilization of leukocytes at the endothelial surface. *Arterioscler Thromb Vasc Biol* 2003;23:1541–7.
- 8 Basile DP, Yoder MC. Renal endothelial dysfunction in acute kidney ischemia reperfusion injury. *Cardiovasc Hematol Disord Drug Targets* 2014;14:3–14.
- 9 Dekker NAM, Veerhoek D, Koning NJ, *et al.* Postoperative microcirculatory perfusion and endothelial glycocalyx shedding following cardiac surgery with cardiopulmonary bypass. *Anaesthesia* 2019;74:609–18.

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