The microcirculatory response during cardiac surgery
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Citation for published version (APA):
Atasever, B. (2012). The microcirculatory response during cardiac surgery
Chapter 1

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Introduction

In 1661, Marcello Malpighi (1628-1694) used a microscope to investigate a frog lung. He was the first to discover long, thin-walled tubes linking arteries and veins, which he termed capillaries. The discovery of capillaries and their surrounding arteriolar and venular components marks the start of early microcirculation research. Nowadays, intravital microscopy, such as Sidestream Dark Field (SDF) imaging, enables bedside visualization and evaluation of the human microcirculation during procedures like cardiac surgery.

In 1953, John Heysham Gibbon (1903-1973) used the first heart lung machine (on-pump) in a human to repair an atrial-septum defect, not having a visualization of the impact of extracorporeal circulation on microcirculatory hemodynamics. In the last decade of the past century, cardiac surgery without the use of extracorporeal circulation (off-pump) was made possible by use of cardiac tissue stabilizers on the beating heart. Off-pump cardiac surgery was generally seen as an alternative to avoid cardiopulmonary bypass-related complications. Both on-pump and off-pump cardiothoracic procedures are routinely performed, and have different influences on systemic and microcirculatory physiology.

The cardiovascular system is responsible for the distribution of blood and its nutritive constituents to all areas of the human body at all times. The microcirculation is part of this system and the site for delivering oxygen to the cells and metabolic exchange. Anesthesia and surgery are generally of influence on the systemic circulation, and may consequently affect microcirculatory function. There is increasing evidence that maintaining microcirculatory perfusion and oxygenation during surgery is essential for the preservation of organ function, and ultimately for outcome. The available studies of microcirculatory changes during cardiac surgery are mostly limited to the use of intravital microscopy imaging techniques to evaluate microvascular perfusion. These studies however lack functional measurements of microvascular oxygenation. In this thesis, integrative monitoring of the functionality of the microcirculation was applied using local spectrophotometric analysis of tissue hemoglobin oxygenation in addition to SDF imaging of microvessel perfusion.

The aim of the thesis was to identify the pathophysiologic mechanisms and responses of the microcirculation, in particular microvascular perfusion and oxygenation, during alterations of systemic hemodynamics caused by on-pump or off-pump cardiac surgery using sublingual intravital microscopy and reflectance spectrophotometry.
Introduction and outline

Outline of the thesis

Chapter 2 reviews available microcirculatory monitoring techniques that are clinically used during cardiac surgery. Functional microcirculatory parameters are described to evaluate the response to hemodynamic alterations during cardiac surgery. Moreover, the distinct effects of hemodynamic and metabolic changes during cardiac surgery are described. The review emphasizes the importance of integrative monitoring to understand the pathophysiologic microcirculatory responses during on-pump and off-pump cardiac surgery.

Chapter 3 recommends uniformity and consistency in microvascular research. Functional hemodynamic analysis of the microcirculatory responses requires more functional parameters.

In chapter 4, the microcirculatory response during extreme hypotension after nitroglycerine treatment is quantified in two patient cases, using both SDF imaging and reflectance spectrophotometry to analyze microcirculatory hemoglobin oxygenation in addition to microvascular perfusion.

In chapter 5 the distinct alterations in microcirculatory perfusion and oxygenation in on-pump and off-pump cardiac surgery are described, and different pathophysiologic mechanisms of microcirculatory failure are identified.

Chapter 6 describes the relationship cardiac displacements during off-pump cardiac surgery with changes in sublingual microcirculatory perfusion and cerebral oxygenation.

Chapter 7 describes the effects of blood transfusion compared to gelatin solution and no transfusion on microvascular perfusion, vascular density, hemoglobin levels and oxygen saturation after on-pump cardiac surgery.

Chapter 8 discusses the clinical implications of our findings and provides directions for future research.

Chapter 9 presents the summary and main conclusions of the present study.
REFERENCES