Development of a new automated Kidney Perfusion System for Organ Conditioning and Function Monitoring

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Motivation – Problem & Background

- Eurotransplant Region, 2014
  - Patients on kidney transplant waiting list: 10,689
  - Deceased donor kidneys transplanted: 3,119

- Actual Trend:
  - Marginal kidney grafts
  - Older donors
  - Extended criteria donors

- Intensification
  - Reperfusion injury after static cold storage (SCS)
Motivation – Possible Solution

- Static cold storage is not enough
- Need for
  - Organ Reconditioning
  - Test for Graft Function
- Possible Solution:
  - Warm machine perfusion of kidneys
- No commercial system available
- Use of individual complex ECLS-Settings
- No standardized, easy to use System or Setup
Perfusion System - Demands

Physiological supply of the organ for the improvement and maintenance of organs functionality

- Storage shell & canulation
- Perfusate
- Perfusate
- Heating
- Oxygenation
- Sensor technology
- Monitoring of the grafts function and automation of the ex-vivo Perfusion
Perfusion System - Prototype

Motivation

Methods

Results

Summary

Homburg

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Perfusion System

Reservoir

Oxygenator

Storage shell

Roller pump

Control PC

Venous blood gas Measurement

Arterial blood gas Measurement

Organ storage and heating

Perfusion Pressure

Gas Supply

Gas Mixture

Oxygenator

Heat Exchanger

Thermostat

Reservoir

Perfusate Temperature

Storage Temperature

Kidney Temperature

Kidney

Urine

Flow

Pump

Homburg, 14.11.2015

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Perfusion System – Automation of Modules

- Automation of subprocesses
  - Focus on safety & robustness
  - Easier to use
  - Faster to learn
  - Better results

- Cascaded control of temperatures
  - Kidney temperature
  - Range: ambient temp. – 38°C

- Roller Pump is flow source
  - Range: 20 – 500 ml/min
• Control of arterial perfusion pressure
  ▪ Changing kidney resistances
    ➢ Automatic adaption of flow
  ▪ Respecting vascular compliance
  ▪ Range: 0 – 180 mmHg

• Control of arterial oxygen and carbon dioxide partial pressures
  ▪ Combination with Terumo - CDI500 for active control
  ▪ Passive gas supply with gas mixer possible (without CDI)
  ▪ Ranges:
    ➢ O2: 40 – 500 mmHg
    ➢ CO2: 20 – 500 mmHg
• Central monitoring and data logging

• Hemodynamic parameters
  - Perfusion pressure
  - Flow
  - Resistance

• Temperatures
  - Kidney, perfusate, heater

• Blood gas analysis
  - $O_2$- & $CO_2$-partial pressures
  - pH
  - Hematocrit
Methods – Experimental Procedure

- Organ retrieval
- Initial flush
- Storage on ice
- Vessel cannulation
- NMP
Results – Achievements and Future Work

• Successful system validation

• Use during 22 kidney perfusion experiments

• Further Aims:
  ▪ Kidney evaluation based on
    ➢ Hemodynamic parameters
    ➢ Autoregulatory behaviour
    ➢ Optical parameters
    ➢ Spectrometric measurements
    ➢ Biomarkers

  ▪ Design of organ storage
    ➢ Avoid loss of perfusate
    ➢ Guarantee adequate perfusion
• Design of a standard system for warm machine perfusion of isolated kidneys

• Automation of the process

• Central process monitoring

• Base for further establishment of organ perfusion!
Thank you!