Master track Medical Sensing and Stimulation

COMBINING TO PROBES TO MONITOR THE CONDITION OF PATIENTS IN SEPTIC SHOCK

Group 10; Elin Biel, Marthe Huntelaar, Jantine Smit, Lyan Vlaskamp

Abstract:
Septic shock is a major cause of mortality in intensive care unit (ICU) patients. Therefore, it is important that these patients are closely monitored, so that actions may be taken quickly if the patient deteriorates. The aim of this project is to describe a new protocol for optimal and non-invasive monitoring of the severity of septic shock and the sufficiency of fluid resuscitation. Special attention is paid to the effect of both of these aspects on the function of the kidneys in patients with septic shock. This was mostly done by an extensive literature research on the currently used techniques and a great deal of 'out-of-the-box'-thinking.
Literature suggests that the microdialysis probe is a promising technique for monitoring the severity of septic shock in ICU patients. The probe is inserted percutaneously into the cortex of the kidney, after which a ratio between the local lactate and pyruvate concentrations can be measured. As patients in septic shock receive fluid resuscitation to accomplish an adequate perfusion of end-organs, it is important to monitor the fluid responsiveness 'state' of the patient. Literature suggested that the intra-abdominal pressure (IAP) is a reflection of the state of fluid responsiveness of the patient. Continuous IAP measurement will thus be included by adding a pressure probe to the urinary catheter, while the volume within the bladder is maintained constant.
The microdialysis probe and IAP measurement were combined in a protocol, which consists of a manual and a flowchart. The combination of both of these techniques provides a complete image of the state of the patient regarding the severity of the septic shock and the state of fluid responsiveness. The protocol and flowchart should be implemented in the ICU to optimize the monitoring process for patients with septic shock.

A new technique to predict fluid responsiveness of patients in septic Shock using renal perfusion pressure, blood flow and oxygen saturation

Group 2; Simone van Nuil, Lisa Rutten, Thomas Urgert, Elisa Verhoeven

Introduction: Septic shock is the main cause of death in the ICU. During shock, acute circulatory
failure leads to inadequate tissue perfusion, multiple organ failure and eventually death. Since the kidneys have a high oxygen consumption, they will fail quickly. Commonly used treatment for shock is fluid administration. Unfortunately, currently used parameters to predict a patient's fluid responsiveness are poor predictors, causing fluid administration to be a complicated procedure to regulate correctly.
Aim: The aim of this paper is to investigate a new technique in which the kidney's macro- and micro-circulation can be used to predict fluid responsiveness in septic shock and determine an optimal terminus for fluid administration.
Method: Different demands are set to invent the right technique to address this problem: The technique should be able to measure the renal perfusion pressure, capillary blood flow and oxygen saturation. It should also be implementable in the ICU with a low risk for the patient. Literature research will be conducted to address this problem.
Results: To agree to these demands a new technique, which combines photoacoustic imaging with microbubbles and their resonance properties, is designed. An indication for the perfusion pressure of the kidney, could be measured with the return of blood pressure dependent resonance frequencies of microbubbles. Furthermore, the combination of photoacoustic imaging and microbubbles will give more insight in the renal capillary blood flow. Finally, oxygen saturation will be measured with photoacoustic imaging.
Conclusion: The resonance properties of microbubbles in combination with photoacoustic imaging is a promising technique to determine renal perfusion pressure, capillary blood flow and oxygen saturation. This is of great value in order to predict fluid responsiveness and regulation of fluid administration for the septic shock patients treated in the ICU. It is recommended to further research this technique.

Beating the struggles of resuscitation

Monitoring renal circulation in septic shock patients

Groep6; Silvano Gefferie, Job de Haan, Anouk Scholten, Kim Wijlens

Abstract

Septic shock

In patients with septic shock, there is a relative circulatory volume depletion which results in less blood supply to the kidney. Therefore, the filtration of the kidney is decreased. Another consequence is the limited oxygen and nutrition supply to the kidney due to the volume depletion, which eventually results in ischemia of the kidney.

Problem

In patients in shock there is no reliable guideline whether or not a patient should receive a fluid resuscitation. Besides, it is desirable to obtain a suitable measure of the functioning of the kidney on micro as well as macro level. Since the technique should be applicable in the intensive care unit and must be relatively easily performed, certain limiting conditions should be satisfied.

Solution:

A catheter is placed in the vena renalis dextra. From here, thermodilution is used to monitor renal blood flow and renal filtration function. To accomplish this, solutions of ornithine decarboxylase and creatinine are used because of their different filtering characteristics.

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Measuring renal perfusion in septic shock patients with NIRS and CVD

Group 5; Laura Treurniet, Maud Hoofs, Marijn Mulder, Mark Smeets

Abstract:
Severe sepsis is a leading cause of death in the developed countries and the most common cause of death among critically ill patients at the intensive care unit (ICU). A frequent and serious complication of sepsis is acute kidney injury (AKI). At the moment it is difficult to monitor the effect of the treatment on the kidney at the ICU.
Macro and microvascular hemodynamic alterations play an important role in the induction of AKI. Fluid therapy is often used to improve overall hemodynamics, but when administered excessively can also induce renal congestion by a high central venous pressure (CVP). This impairs the bloodflow to the kidneys and decreases the GFR and medullary oxygenation. Also, renal medullary hypoperfusion can occur due to a redistribution of renal blood flow to cortical areas. The medulla is usually performing in hypoxic conditions, therefore a further drop in oxygenation can cause AKI.
We propose a method to find the optimal conditions in which the perfusion of the medullary areas is sufficient but with a relatively low CVP to prevent renal congestion. The CVP will be measured with a CVP catheter located at the site of the right atrium. The medullary oxygenation will be measured using an intra pelvic NIRS measurement device to receive direct values of the medullary oxygen status. The NIRS probe is inserted through a double J ureteral stent and placed directly in the renal pelvis. We assume that this method can give the clinician at the ICU values to guide the hemodynamic therapy with an aim to reduce the occurrence of AKI in septic patients.

Targeted and filled microbubbles as a new approach to quantify the renal microcirculation's functionality

Group 8; Rubben Dollen, Koen van der Sluijs, Vivianne de With, Vincent Wolbert

Septic shock presents itself as a serious disturbance of the circulatory system; it might result in a compromised perfusion of vital organs. Fluid resuscitation is used to stabilise patients in order to keep them alive. Once stabilised, failure of organs is often noticed. Research has shown that the most common complication associated with septic shock is acute kidney injury, which occurs in around 40% of septic shock patients. The exact pathogenesis is still unknown and hard to investigate given the ethical restrictions of performing invasive studies on critically ill patients. The current belief is that alterations of the renal microcirculation are the major cause of acute kidney injury. Still, more insights in the development are needed in order to prevent it from happening and as a foundation for treatment plans. A non-invasive, reliable, bedside monitoring technique of the renal microcirculation is desired to achieve this.
A solution to monitor the renal microcirculation is proposed. The solution is to inject microbubbles, that are targeted at the kidneys, into the circulation. These microbubbles contain substances that react to the changes of the renal microcirculation. Using ultrasound, the microbubbles will burst, releasing the substance and thereby allowing them to react to alterations of the renal micro-circulation. The ratio of reacted versus unreacted substance can be measured via a catheter in the renal vein. From this ratio, conclusions about the renal microcirculation can be drawn. In this way, therapy could be altered to fit the optimal save of the microcirculation's functionality.
Further research is required to find out the effectiveness of this new approach.

Concentration deduced renal perfusion measurement for patients in shock

Group 7; Tijmen Elfrink, Thijs Nassi, Lieke Numan, Raymond van Wijk

Abstract

Introduction

The assessment of the renal microcirculation of a patient in circulatory shock is considered a major topic in ICU medicine. If the patient survives the critical phase of shock, there is still a substantial risk of renal failure. Therefore, there is an increasing need for a bedside method to determine the renal perfusion in an early stage on the ICU. This method can help the clinician in the decision making when treating patients in shock.

Method

Current techniques were reviewed by consulting literature and specialists. Several techniques were taken into consideration. Next, the acquired knowledge is used to devise a new method for assessment of the renal microcirculation.

Results

A new technique is suggested in which the renal microcirculation is determined via the glomerular filtration rate (GFR) and a concentration deduced renal perfusion measurement. The technique overcomes the major flaws of existing techniques.

Conclusion

A framework of a new method to assess kidney perfusion has been devised. However, more research is needed to refine and realise this technique on the ICU.

Discussion

Extensive research is needed in order to build upon the devised framework. Some of the areas that should be focused on are the sensitivity and catheter placement. Furthermore, determining the GFR of patients in shock is also an area of interest.

The monitoring of fluid administration by a renal venous catheter in patients with septic shock

Group 4; Maartje Dekker, Mireille Kamminga, Athra Malki, Cindy Rikhof

Abstract

Sepsis is one of the leading causes of death in critically ill patients in the non-coronary intensive care unit. It leads to severe microcirculatory dysfunction and hypoxemia, resulting in multiple organ failure including acute kidney injury (AKI). Fluid administration is a way to treat septic shock, however excessive fluid administration can reduce renal oxygenation, which contributes to AKI as well. To prevent AKI (or exacerbation of AKI), it is necessary to find the optimal amount of fluid administration. The aim of this research is to obtain a new method that monitors the fluid responsiveness when fluid administration is used in patients with septic shock. Improvement of the renal function corresponds with fluid responsiveness. To measure the renal function, oxygen saturation (SO2) differences between arterial and venous blood will be measured with a pulse oximeter and a renal venous catheter, positioned in the renal vein, respectively. In case of hypoperfusion, the renal oxygen consumption will increase as a result of hemodilution and in this situation the kidney will still be fluid responsive. However, excessive fluid administration will cause renal microcirculatory dysfunction and a fall in renal oxygen consumption, so additional fluid administration has to be terminated. Besides SO2, biomarkers in the blood will be monitored. The treatment will be adapted according to the monitoring information, but will consist of a combination of hemodilution and drug therapy. Future research should focus on investigating the efficiency of the catheter and the possibility to produce a less invasive monitoring device.

Monitoring of renal microcirculation with Contrast Enhanced EIT

Group 1; Ditte Moejes, Rob Warnaar, Nynke Wijbenga, Loes Zaremba

Abstract

Sepsis-induced Acute Kidney Injury (AKI) is a frequently occurring problem within the Intensive Care Unit setting, accompanied by a prognoses of increased morbidity and mortality. At the moment, there is no valid method for the evaluation of the progression of septic shock along with AKI. Therefore, in order to determine the effects of fluid resuscitation a new technique in the Intensive Care Unit (ICU) setting is needed.

Contrast Enhanced Ultrasound (CEUS) is a technique currently researched for its applicability to monitor renal microcirculation. Its operator dependency is an important issue to overcome. Since the microbubbles used in CEUS might as well be suited as a contrast agent for Electrical Impedance Tomography (EIT). This research focuses on the feasibility of Contrast Enhanced EIT (CEEIT) in monitoring renal microcirculation in ICU patients and the steps to implementation in ICU practice.

EIT is a relatively cheap method when used frequently. It can be applied at bedside and is non-invasive. Furthermore when the electrodes are applied, every ICU nurse can execute and interpret the proposed measurement. However, literature research is inconclusive whether the impedance differences induced by microbubbles might be large enough to map renal perfusion. Therefore, in vivo experiments with healthy subjects and/or ICU patients are recommended and are the most important step to investigate feasibility.