

Master track Medical Sensing and Stimulation

Measuring mean systemic filling pressure during routinely used ventilation

Groep 1; Lieke Hermans, Thijs Hakkenberg, Sandra Horsten, Jantine Schotman

Abstract

Administering fluid is important to maintain adequate tissue perfusion in ICU patients but volume overload can cause unwanted side effects. Ideally a static index could be developed that can be a measure of volume status without being affected by cardiovascular compensation mechanisms. Mean systemic filling pressure (P_{msf}) - the blood pressure when there is no blood flow- could perhaps be a suitable option. At the moment P_{msf} is not routinely used to assess the volume status of a patient, mainly because current measurement methods are not yet suitable for easy bedside measurement. Additional disadvantages of the current methods are the need for mechanical ventilation and the insertion of invasive lines. Therefore we have thought about a new measurement method that is based on the same physical laws and assumptions that the inspiratory hold method relies on but has fewer limitations. With both techniques a variable positive pressure is applied to the thorax by mechanical ventilation, which results in an increase in intrathoracic pressure and a decrease in cardiac output (CO). The difference is that instead of measuring CO and RAP after an inspiratory hold we aim to measure these parameters from the variation during normal ventilatory and respiratory cycles. By measuring CO variations arising from variations in right atrial pressure (RAP) the P_{msf} can be determined, which is done by extrapolating the RAP-CO curve to zero. To make the improved method suitable for adequately measuring P_{msf} , CO and RAP need to be recorded continuously, accurately and preferably non-invasively. The existing methods are sufficiently accurate but still invasive, although non-invasive techniques are emerging. Additionally, recorded variations of RAP and CO should be large enough to enable extrapolation. The CO variations in routinely used mechanical ventilation are smaller than with the inspiratory hold method, but we estimate them to be large enough. Variations in spontaneous respiration are much smaller and therefore probably cannot be used to assess P_{msf} yet. To eventually extend the method to spontaneously breathing patients, a solution for this has to be found.

Mean systemic filling pressure; a physiological approach

Groep 2; Marly van Assen, Michelle van den Boorn, Laura Koot, Joannet Onvlee

Abstract

Accurate assessment of the cardiovascular state in critically ill patients is difficult. Therefore, identifying the appropriate therapy and targeting specific measurable end-points of therapy are problematic. The mean systemic filling pressure (Pmsf) can be a good marker of effective blood volume and would be an important variable to measure in patients at the Intensive Care. With a known Pmsf the cardiovascular status and fluid responsiveness can be determined. Currently there are two techniques to measure the Pmsf, the inspiratory hold method and the arm-stop flow method. One of the main disadvantages of these two methods is that the changing vascular resistance is taken constant. In critically ill patients the vascular resistance can greatly vary. The new method takes this change into account. The new method is developed based on physiological laws as Poiseuille's law. In order to get continuous measurements a new catheter is used.

Mean systemic filling pressure: Bed-side measurement with cardio balloon in right atrium

Groep 3; Ingrid Koopmans, Jorinde Kortenbout, Paul Smits, Eline van Staveren

Abstract

50% Of fluid challenges in septic shock patients are successful and increase cardiac output. However, giving fluid therapy can be dangerous and it may decrease patients outcome. Improved hemodynamic monitoring is required to diagnose if a patient will react positive to fluid therapy. The pressure of stressed volume during cardiac arrest is the mean systemic filling pressure (MSFP) and it drives the venous return, which causes the cardiac output. Measurement of MSFP will realize a better evaluation of the fluid status of the patient. Prior methods to measure MSFP require stopping the blood flow or using mechanical ventilation. In the new method a catheter is used to inflate a balloon in the right atrium, which will increase the right atrial pressure. By measuring this increasing pressure and simultaneously the matching cardiac output, a venous return curve can be created. This curve contains the MSFP, which is the crucial factor for predicting the fluid responsiveness in patients.

Using the arterial line to determine the MSFP

Groep 4; Stijn Hinssen, Hanneke Keijzer, Ruud van Leuteren, Dennis Rebergen

Abstract

Introduction: at the ICU, a very broad range of patients is treated. To provide the best treatment for a patient, it is important to know whether or not a patient needs extra vascular volume. Many complications derive from an altered volume status, but it is very difficult to estimate the current volume status of the patient. A new parameter that might be a sign for the blood volume is the Mean Systemic Filling Pressure (MSFP). In this article, the two most important and most often used methods to determine this pressure are described, followed by a possible new way to determine the MSFP.

Methods: by use of a model of the cardiovascular system, the MSFP is determined for different amounts of stressed volume by simulating a cardiac arrest. The goal is to calculate this value from the arterial blood pressure curve by making an exponential fit of the pressure decay. At the hospital, the arterial blood pressure curve is continuously measured with an arterial line. With this fit and the parameters: heart rate, stroke volume and blood pressure, the MSFP can be estimated. The final goal is to find a way to calculate the MSFP from the patient's arterial blood pressure curve.

Results: at different volume statuses, the exponential fit, the values for the parameters and the MSFP varied. These results were arranged in a table for further analysis.

Conclusion: the model is able to determine a value for the MSFP. The MSFP cannot be calculated yet by using the continuous arterial line signal. It has however been shown that the MSFP depends on the parameters mentioned above.

Discussion: although there is a correlation between the MSFP and the volume status, i.e. the fit and the different parameters, the MSFP cannot be calculated yet from the arterial line. Further research can make it possible to make a function that calculates the MSFP from the arterial blood pressure curve

The Patient Tilt Technique as a new method for measurement of MSFP in critically ill patients

Groep 5; Niala den Braber,, Erik Huizinga, Eline KleinJan, Nicole Rommens

ABSTRACT

Introduction: Control of the volume state is the most important therapy in critically ill patients. The Patient Tilt Technique presents a new method of measuring the mean systemic filling pressure (MSFP), which can be used to predict fluid responsiveness of patients. This paper describes the design and development of the Patient Tilt Technique. Methods: Tilting the bed in different angles results in various pressures and corresponding flows in the cardiovascular system, which are plotted in a graph. The pressure corresponding to a flow of zero can be extrapolated from these data points. This pressure is the MSFP, since the MSFP equals venous pressure when flow is absent. The pressure and flow can be measured in an invasive and non-invasive way. The invasive method is fully automated. It consists of a new catheter with a Doppler Flow transducer combined with a pressure transducer at the tip, inserted in the jugular vein. The non-invasive method measures the flow and pressure by a combination of Doppler Ultrasound in the brachial and jugular veins. Discussion: The Patient Tilt Technique includes most patient populations. This makes it more applicable on a critical care ward. A difficulty of the method is the absence of hospital beds that satisfy the requirements of the technique, it would not be economical to replace all ICU beds with new developed beds for this method. Furthermore, the accuracy of the technique depends on the accuracy of pressure and flow measurements. The accuracy is also decreased due to the non-linear pressure-flow relation, which can result in an imprecise extrapolation. On the other hand, the non-invasive method can be applicable for routine patient care. Conclusion: In theory, the Patient Tilt Technique is a promising technique to measure the MSFP. Further research is required to determine the feasibility of the method in an ICU environment.

Balloon inflated MSFP measurement

Groep 6; Mattiënne van der Kamp, Lara Mentink, Martijn Schreuders, Ellis Wicking

Abstract

Fluid therapy is a key factor in management of patients in the intensive care unit (ICU). Fluid therapy can promote the cardiac output (CO) and improve the outcome of these patients. Sometimes this intervention does not promote the CO and it can result in volume overload. Volume overload can lead to severe complications such as generalized edema and lung edema, heart failure and an increased mortality. To predict the effect of a fluid challenge, a proper hemodynamic parameter is required. Recent research is focused on mean systemic filling pressure (MSFP), a parameter that reflects the pressures in the vascular system when flow equals zero. This research project uses literature study to determine the current role of the MSFP in a clinical setting. Three different MSFP measurements are evaluated. The main focus of the project is to add an alternative MSFP measurement. Results of the literature study lead to a new technique called Balloon Inflated MSFP measurement (BIMM). In this method a balloon is used to induce different levels of occlusion in the vena cava. Pressure measurements at different

occlusion levels are used to determine the MSFP by interpolating these results in the venous return curve. This measurement can be seen as an additional MSFP evaluation and can be used for further evaluation of the role of fluid challenges in ICU patients. More research is required to evolve this concept in a method that can be successfully used in the ICU.

Mean Systemic Filling Pressure: A non-invasive Arm Occlusion Measurement

Groep 7; Jasper van der Heijdt, Carola van Os, David Roelofs, Geke Roth

Abstract

Purpose: to investigate an improved way to measure the mean systemic filling pressure (P_{msf}) as a parameter to assess fluid responsiveness.

Solution: the arm occlusion pressure (P_{arm}), obtained by obstructing the arm blood flow, is assumed to be a good indicator of P_{msf} . By using the Finapres instead of a radial arterial line the P_{msf} can be measured non-invasively and at an earlier stage than is possible now.

Discussion: this technique can be used for automated and non-invasive measurements. However, the Finapres cannot measure static pressures below 40 mmHg at this moment. Its accuracy also needs improvement before this technique is applicable.

Conclusion: Using the Finapres in combination with the arm occlusion technique could be a viable measurement method for the P_{msf} .

Groep 8; Eliene Brand, Stefan Engelhard, Annemijn Jonkman, Ruud van Kaam

Abstract

Evaluating hemodynamics to predict effective tissue perfusion is a difficult task, since no evidence-based indicator currently exists for diagnosing volume status. With the knowledge that without filling of the heart, no cardiac output can be achieved, the venous part of the circulation is now being studied more often. The main focus of this report will be on the driving force for venous return, the mean systemic filling pressure (P_{msf}).

Two methods to measure P_{msf} , the breath hold and arm stop flow techniques, are reviewed.

Suggestions for further development of the arm-stop-flow are then discussed. The focus lies on the determination of the vascular permeability in patients with septic shock, which leads to misleading values of P_{msf} if this is not taken into account.

