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SPECIAL ARTICLE

Plasmapheresis and other extracorporeal filtration techniques in critical patients

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Abstract Plasmapheresis is an extracorporeal technique that eliminates macromolecules involved in pathological processes from plasma. A review is made of the technical aspects, main indications in critical care and potential complications of plasmapheresis, as well as of other extracorporeal filtration techniques such as endotoxin-removal columns and other devices designed to eliminate cytokines or modulate the inflammatory immune response in critical patients.

PALABRAS CLAVE
Plasmaféresis;
Eliminación de componentes sanguíneos;
Endotoxinas;

Plasmaféresis y otras técnicas de depuración extracorpórea en pacientes críticos

Resumen La plasmaféresis es una técnica extracorpórea mediante la cual se procede a la eliminación de macromoléculas del plasma que se consideran mediadores de procesos patológicos. En este artículo se revisan los aspectos técnicos, las principales indicaciones en las patologías que suelen motivar ingreso en la Unidad de Cuidados Intensivos y las potenciales

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complicaciones de la plasmaféresis. Así mismo, se incluye una revisión de otras técnicas de depuración extracorpórea, tales como las columnas de fijación de endotoxinas y otros procedimientos que persiguen la eliminación de citoquinas o la inmunomodulación del proceso inflamatorio en el paciente crítico.

Plasmapheresis in critical patients

Abel et al.[1] performed the first plasmapheresis procedure in 1914. In the 1970s, plasmapheresis was increasingly used to treat various conditions,[2] but it was not until the 1990s that a consensus was reached about the specific but limited number of diseases for which it confers a definite benefit.[3]

In plasmapheresis, the plasma is separated from the blood and is processed to selectively eliminate some of its components. After processing, the plasma is reinfused. Plasma exchange is defined as the procedure in which the plasma is separated from the blood and replaced by a replacement fluid. In clinical practice, the terms plasmapheresis and plasma exchange are used synonymously, although in the vast majority of occasions, the plasma separated from the whole blood is eliminated and replaced with the same volume of another solution.

The exact mechanism through which plasmapheresis exerts its therapeutic effect is unknown, although it seems likely that plasmapheresis could work by eliminating pathologic substances from the plasma or decreasing their concentration. These harmful substances can include antibodies, immunocomplexes, monoclonal proteins, cryoglobulins, complement components, lipoproteins, toxins bonded to proteins, and other, unknown substances.

Indications

Plasmapheresis has been used to treat diverse pathologies, especially in the fields of neurology, hematology, and rheumatology, although the grade of evidence for these treatments varies. The American Society for Apheresis (ASFA)[4] periodically revises the indications for plasmapheresis and classifies them according to the Grading of Recommendations Assessment, Development and Evaluation (GRADE) criteria.[5] Table 1 shows the Grade I indications (first-line therapy) and the Grade II indications (established second-line therapy). Table 2 lists the most relevant pathologies that could require therapeutic plasmapheresis in critical care patients, as well as the modality, clinical context, category, and grade of recommendation.

Technical aspects

For most indications, the goal is to exchange from 1 to 1.5 times the volume of plasma, which is usually estimated with the following formula:

$$\text{Estimated plasma volume(L)} = 0.07 \times \text{weight(kg)} \times (1 - \text{hematocrit}^{*}).$$

$^{*}\text{Hematocrit} = \%[\text{hematocrit}]/100$

Methods of separation

The methods used to separate the plasma from the blood can be divided into centrifugation and filtration. Centrifugation is the older method, based on the separation of cellular elements from the plasma by rapid spinning, in which centrifugal force separates the different components according to their density, size, and molecular weight. This method has the advantage that there is no upper limit to the molecular weight of the substances to be separated out. It makes it possible to perform cytapheresis, in which cells of interest can be removed for therapeutic purposes or for later donations. The main drawback of centrifugation is the risk of thrombocytopenia. Moreover, it requires anticoagulation with citrate, so it can lead to hypocalcemia. Centrifugation is the method used by blood banks; it requires sophisticated difficult-to-transport equipment that limits its use in therapeutic apheresis in critical care environments.

In filtration, the cellular components of blood are separated from the plasma by passing the blood through a filter with large pores (0.2–0.7 μm) that extracts molecules weighing up to 3 million Da. The mechanism of separation consists of applying pressure to transfer the blood across a synthetic membrane that is highly permeable due to the large size of its pores. This membrane is the central element of an extracorporeal circuit, similar overall to those used in intensive care units (ICU) for other purification treatments such as continuous renal replacement therapy (CRRT) or extracorporeal albumin dialysis with the molecular adsorbent recirculating system (MARS®). This approach requires a central venous catheter and anticoagulation with heparin. The advantages of filtration include the low risk of thrombocytopenia and the possibility of eliminating more plasma in less time. This approach also enables double filtration or cascade filtration in which the first filter separates the plasma, which is in turn passed through a second filter that has the capacity to selectively separate out certain molecules through filtration or adsorption.

Vascular access

Vascular access and blood flow through the extracorporeal circuit are fundamental for the success of the procedure. Vascular access can vary depending on the